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T200
PROGRAMMABLE
SERVO DRIVE

USER'S MANUAL

C27095-001

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T200 Servo-Drive Manual Overview

This manual is broken into 11 sections and 1 Appendix.

Section 1 is an overview of the functionality of the T200 Product Family. It outlines technical features and data of the T200.

Section 2 is description of critical safety issues. It also outlines particular installation and configuration items that the user must implement if the target machine installation is required to be CE-Marked. This section should be read by all users, especially those who are installing a T200 for the first time.

Section 3 describes installation and wiring for the T200 and the servo-motor. It describes T200 mounting, terminal connections and external components.

Section 4 is a description of Moog motors. It deals with motor mechanical issues. Section 4 also outlines how to configure the T200 servo-drive for standard and non-standard motors.

Section 5 is a Quick-Start guide, for use with WinDrive, the MS-Windows setup and monitoring package.

Section 6 is a functional description of the T200. It contains explanations of how the Inputs of the T200 affect functionality and how Outputs reflect status and other information. It describes how to tune control loops.

Section 7 is a description of the WinDrive user interface, including details on motor and optional T200 feature configuration. It describes how to use WinDrive for tuning and diagnostics.

Section 8 is a description of the Hand Held Terminal user interface.

Section 9 contains wiring instructions on the Controller Area Network interface.

Section 10 is a Troubleshooting guide.

Section 11 contains Sales Outlet information.

Appendix A describes EMC test configurations, under which the T200 was tested for compliance with the European Union's Electro-Magnetic-Compliance (EMC) Directive, in various T200 model and I/O configurations.

This manual describes the functionality and features of the present version of the T200 Product Family. Not all of the described features are available in previous versions of the T200.

Information contained herein is subject to change without notification and should not be construed as a commitment by Moog Inc. This manual is periodically reviewed and revised.

Moog Inc. assumes no responsibility for any errors or omissions in this document. Critical evaluation of the manual by the user is welcomed. Your comments will assist us in future product documentation.

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Rev	Description	Date	Effectivity
Preliminary	Preliminary version of the T200 Manual	21/Oct/98	All
First Issue	First version of the T200 Manual	31/March/99	All
Second Issue	Revised version of the T200 Manual. Added description of additional features as implemented in A8/B8/P8 software and T200-3/4/5XX**G**, T200-610**D**, T200-710**C** hardware. Added features are: - Error logging - Fault detection via digital outputs - Extended regen resistor protection scheme - Extended functionality of Stepper Mode - Personality Plug - Output impedance of testpoints changed from 10kΩ to 100Ω	15/Sep/00	All
A	*First release under Moog Ireland Part Number C27095-001.* *Previous revisions are stated to reflect document history.* Revised version of the T200 Manual. Added features are: - UL approval for T200-3/4/5XX - Changes for WinDrive2.2 (also changes necessary to reflect entire functionality of WinDrive) - Added POD commands for inverting output polarities - Extended meaning of F3 fault (DC bus fuse blown now included in this fault)	07/May/02	Sections 1, 7, 8, 10

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SECTION 1: T200 OVERVIEW

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1.1 Introduction

This section gives an overview of the available T200 models, ratings and general specifications. Detailed outlines of installation and wiring, functionality, user interfaces and other technical data are given in later sections.

CAUTION: Repairs or modifications to the product by anyone other than a Moog authorized repair facility may create unsafe operating conditions and will invalidate the product warranty.

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1.2 T200 Models

The T200 family is available in eight base models. These eight models cover a range of output current ratings and include units either with or without integral high voltage power supplies as shown below.

T200 Base Model	Amplifier Current Rating (Arms)	
Units with High Voltage Power Supply	Continuous Current	Peak Current
T200-310	5	10
T200-410	10	20
T200-510	20	50
T200-610	40	80
T200-710	60	140
Units without High Voltage Power Supply	**Continuous Current**	**Peak Current**
T200-300	5	10
T200-400	10	20
T200-500	20	50

Table 1.1: T200 Family Models

These devices are intended for installation in a pollution degree 2 environment.

The T200 family uses a 13 character coding system to identify the unique attributes of each model. The coding system is shown below:

T200 - AAAB - C SW

SW designates the Embedded Software Version
- Ax for standard drive functionality
- Bx for CAN Interpolation Mode functionality
- Px for custom POINT motion control

(where x is the release revision number)

C designates the Option Cards
- 0 for no option card
- 1 for POINT extended I/O card
- 2 - 9 reserved

B designates the hardware revision

AAA designates the Base Model
- see description above in Table 1.1.

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Moog also provides a variety of accessories for the T200. Examples include:

- Operator terminals for applications requiring a user interface
- Hand held terminal for drive configuration and diagnostics
- EMC cable brackets for securing cable and grounding shields at the T200 (see Section 3.14.5)
- Personality plug for automated drive configuration
- Quick connect cables for interconnecting drives in a multi-axis application (see Section 3.1.8)
- Preconfigured motor cables
- Backup logic power supplies
- Step down transformers

Please consult your local Moog sales office or authorized distributor for part number and availability of these or other products.

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1.3 Environmental Specifications

T200 Electronics

Temperature for transport and storage:	-25 °C to 70 °C
Operating temperature:	0 °C to 55 °C
Relative Humidity:	5 % to 95 %, non-condensing, 1 g/m^3 to 25 g/m^3, in accordance with EN50178 class 3k3
Elevation:	3300feet Derate output 2% per 1000 feet above 3300 feet
Type of protection:	Components must be installed into an enclosure. The enclosure must provide at least IP54 per standard EN60529 or equivalent.
Installed position:	Vertical only.
Overvoltage protection class:	Category 2 per standard VDE0110 / IEC664
Noise:	Overall noise depends on the user installation and cabinet. Noise from the electronic components is less than 55dBA.

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1.4 Design Standards

The T200 has been designed to EN50178. It is CE-Marked under the EU's Low Voltage Directive. It has been designed to allow easy compliance of customer's machines under the EU's EMC Directive (measures as directed in this manual have to be taken to ensure EMC compliance). It is designed to the UL508C standard. T200 models –3xx, -4xx and –5xx are UL-marked. UL is pending on the –610/710.

The T200 is considered professional equipment. Professional equipment is defined as equipment for use in trades, professions, or industries and which is not intended for sale to the general public.

The T200 has been designed to the following specific standards:

Guidelines for engineering design	EN 50178
Dimensioning of creepage distances and clearances	EN 50178
Insulation coordination	IEC 664
General safety requirements	EN 50178
Reliable isolation	EN 50178
Marking	EN 50178
Grounding	EN 50178
Overvoltage protection	EN 50178
Ambient conditions	IEC 68 Part 2-3, 2-6
Short-circuit strength	EN 50178
Mechanical stresses	IEC 68 Part 2-29
Protection by limitation of discharge energy	EN 50178
Type-testing	EN 50178
EMC	EN55011 EN50082-2
UL	UL508C with reference to UL840

Table 1.2: T200 Design Standards

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1.5 Power Ratings Specifications

The T200 family includes models with and without high voltage Power Supply Units (PSU's). These PSU's generate a high voltage D.C. Bus by rectification of A.C. Mains. T200 models with PSU can supply D.C. Bus power to other T200 units which do not contain integral PSU's via D.C. Bus interconnect wiring. All current ratings are specified in ampere r.m.s., unless otherwise stated.

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1.5.1 Units with A.C. Mains Input Interface (T200-310 to T200-710)

All current ratings are specified in ampere r.m.s.

	T200-310	T200-410	T200-510	T200-610	T200-710
AC Mains Input Range **Minimum** **Maximum**	100Va.c. (120Va.c. -15%) 255Va.c. (230Va.c. +10%)			195Va.c. (230Va.c. -15%) 255Va.c. (230Va.c. +10%)	
Frequency Range	50..60Hz				
Continuous Input Power					
Three-Phase **Single Phase 230Va.c.** **Single Phase 120Va.c.**	7.5kW 2.5kW 1.2kW			15kW Not Available Not Available	
Max Rated Input Power (for 15 seconds)					
Three-Phase 230Va.c. **Single Phase 230Va.c.** **Single Phase 120Va.c.**	15kW 5.0kW 2.4kW			30kW Not Available Not Available	
Maximum Number of T200-X00's (units without A.C. Mains PSU) which can be connected to a T200-X10	***four*** Note that application power requirements will also set a limit on the number of T200-X00's (i.e. units without Mains PSU) which may be connected to a T200-X10 (unit with Mains PSU). See Section 3.10 for guidelines on how to match application power requirements for each T200-X10 unit.				
D.C. Bus Rated Continuous Output Power (T200-310 to T200-710)	20Ad.c. at 325Vd.c. (6.5kW)				
Internal Regeneration Power					
Continuous Dissipation **Peak Dissipation**	40W 2.8kW			No internal regen capability	
External Regeneration Power					
Continuous / Peak	200W / 14kW (1 * 50Ω)	600W / 14kW (1 * 10Ω)		600W / 14KW (1 * 10Ω) 1250W / 18kW (1 * 8Ω) 2000W / 28kW (2 * 10Ω) 2500W / 36kW (2 *8Ω)	
Soft-start Peak Inrush Current/Phase	7Apeak				
Power Supply Fault Detection	A.C. Mains not present D.C. Bus Overvoltage Internal Regeneration Fuse Blown Power Supply Temperature Fault				
Voltage Discharge after A.C. Mains Removal	Fast Bus Discharge function Bleed Resistors across high voltage section				
Power Sequencing Control	Power Ready output provided to control power application				

Table 1.3: T200-X10 Power Ratings

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1.5.2 Units with D.C. Bus Input Interface (T200-300, T200-400, T200-500)

All current ratings are specified in ampere r.m.s. unless otherwise stated.

Nominal D.C. Bus Voltage	325Vd.c. (generated from rectified 230Va.c.)
D.C. Bus Maximum Voltage	400Vd.c. (generated from rectified 280Va.c.)
Maximum Continuous Input Current **T200-300** **T200-400** **T200-500**	 5Ad.c. 10Ad.c. 20Ad.c.

Table 1.4: T200-X00 Power Ratings

1.5.3 Optional Control Logic Backup Power

D.C. Bus Minimum Voltage (below which 24Vd.c. or 120Va.c. Control-Logic Backup supply is needed)	250Vd.c. (generated from rectified 170Va.c.)
24V Input	18Vd.c. to 36Vd.c. 2.0A inrush current /axis 1.5A steady state Internal Resettable fuse in case where polarity has been reversed
120Va.c. Input	+10%, -15% voltage range 0.3Ar.m.s. /axis

Table 1.5: T200 Control Logic Backup Power Ratings

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1.5.4 Power Amplifier

All current ratings are specified in ampere r.m.s. unless otherwise stated.

Power Amplifier Ratings ($A_{r.m.s.}$):		**Max. Time at I_{peak}**
T200-3	$5A_{continuous}/10A_{peak}$	10s
T200-4	$10A_{continuous}/20A_{peak}$	10s
T200-5	$20A_{continuous}/50A_{peak}$	2s
T200-6	$40A_{continuous}/80A_{peak}$	2s
T200-7	$60A_{continuous}/140A_{peak}$	2s

Table 1.6: T200 Power Amplifier Ratings

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1.6 General Functional Specifications

1.6.1 Digital Inputs

- All Optically Isolated, 12 .. 32V Input Range.
- 2.5kOhm input impedance.
- Pull-Up or Pull-Down from I_COMMON line.

J1 Pin Name (Pin Number)	**10V Torque or Velocity Analog Reference**	**Stepper Interface Mode**	**Digital Inputs Speed Mode**	**CAN Mode** ① **Profile Mode Interpolation Mode**	**Point Mode**
ENABLE (5)	High Power Enable Input	High Power Enable Input	High Power Enable Input	High Power Enable Input	High Power Enable Input
PWR_RDY (6)	Power Ready Input	Power Ready Input	Power Ready Input	Power Ready Input	Power Ready Input
AUTO_MAN (7)	Auto/Manual Mode	Auto/Manual Mode	Auto/Manual Mode	Auto/Manual Mode	Auto/Manual Mode
TRQ_VEL (8)	Torque-Velocity Mode Switch	*Not used*	*Not used*	① Home-Switch User defined	General purpose input
CW_LIM (9)	Clockwise Limit Switch Input	Clockwise Limit Switch Input	Clockwise Limit Switch Input	① Clockwise Limit Switch Not used	General purpose input (default) OR Clockwise Limit
CCW_LIM (10)	Counterclockwise Limit Switch Input	Counterclockwise Limit Switch Input	Counterclockwise Limit Switch Input	① Counterclock-wise Limit Switch Not used	General purpose input (default) OR Counterclockwise Limit Switch Input
BRK_IP (11)	Brake Control	Brake Control	Brake Control	Brake Control	General purpose input (default) OR Brake Control
ROT_DIR (12)	Reverse Direction	*Not used*	Reverse Direction	*Not used*	General purpose input
PROG_SPD_1 (13)	*Not used*	*Not used*	Programmable Speed 1	① Not used Quick-Stop	General purpose input
PROG_SPD_0 (14)	*Not used*	*Not used*	Programmable Speed 0	① Not used User defined	General purpose input ***OR*** Fast Encoder Registration

* Note that CAN Interpolation Mode uses the PROG_SPD_1 digital input as a Quick-Stop digital input.

Table 1.7: T200 Digital Inputs Overview

See Section 3.15 for a full description of the digital inputs electrical format, conventions and functionality.

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1.6.2 Digital Outputs

- All outputs are Optically Isolated.
- Maximum ratings of 36V, 50mA.
- Pull-Up or Pull-Down from O_COMMON line.

J1 Pin Name (Pin Number)	10V Torque or Velocity Analog Reference	Stepper Interface Mode	Digital Inputs Speed Mode	CAN-Profile, Inter-polation Mode	Point Mode
THRM_LIM (19)	Limit Activated	Limit Activated	Limit Activated	Limit Activated	Limit Activated
DRV_ENBLD (20)	Drive Enabled	Drive Enabled	Drive Enabled	Drive Enabled	Drive Enabled
SPD/TORQ_ ACHVD (21)	Speed/Torque Achieved	Position Following Error	Speed/Torque Achieved	Speed/Torque Achieved	General purpose output
SPARE_DIG_OP_1 (27)	Fault Code Bit	Fault Code Bit	Fault Code Bit	User defined	General purpose output
SPARE_DIG_OP_2 (28)	Fault Code Bit	Fault Code Bit	Fault Code Bit	User defined	General purpose output

Table 1.8: T200 Digital Outputs Overview

1.6.3 Other I/O

2 Analog Inputs	Analog Command (±10V, 12 bit, 10kΩ input impedance) Analog Torque Limit (±10V, 12 bit, 10Ω input impedance)
2 Analog Outputs	Programmable Test Point 1 (±10V, 12 bit, 100Ω output impedance) Programmable Test Point 2 (±10V, 12 bit, 100Ω output impedance)
Brake Control	3,5A, 30Vd.c. relay provided. Switched under user control or T200 software control.
Motor Position Feedback Type	Resolver Based
Incremental Encoder Interface	1 channel 1MHz RS422 Channel Input 5V/100mA power output with resettable fusing.
Communications Interfaces	**Controller Area Interface** CANOpen (ISO11898) hardware-interface format (RS485 interface also included on spare pins of 9 Way Sub-D Connector. See Section 9.) Optically Isolated (internally supplied power) 5kBaud to 1MBaud programmable RS232 Interface at 9600Baud RS485 Interface at 9600Baud

Table 1.9: T200 Miscellaneous I/O Summary

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1.6.4 Software Control Modes

±10V Torque, Velocity and Position Mode
Analog reference for torque, velocity or position slave mode. Encoder Simulation as standard.

Stepper Motor Emulation Interface (Positioning Mode)
T200 will emulate a stepper motor drive, with a Quadrature or STEP/DIR input format.

Digital Reference Speeds
T200 uses two digital inputs to set the reference speed. Speeds are software programmable.

CAN Interpolation Mode
- Fine Interpolation of Position Commands at up to 2ms command rate
- Parameterisation via CAN

CAN Profile Mode
- Point to Point, Jog, Relative/Absolute moves etc.
- Velocity Mode
- Electronic Gearing and CAMing
- Parameterisation via CAN

Point Stand Alone Motion Control Capability
- Motion Control Language
- Servo-Control Algorithms
- Extended Digital I/O Capability

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SECTION 2: SAFETY INSTRUCTIONS

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2.1 General

This user's manual is intended to provide sufficient information on how to install, wire and tune a Moog brushless electric motor system which includes all of the equipment outlined in Section 3.1. Section 2.2 covers Safety and System Safeguards. Section 2.3 covers Electromagnetic Compatibility (EMC). This user's guide must be read and understood before applying power and operating the equipment described.

This equipment must be installed and serviced only by duly qualified service personnel. All information in this manual is directed towards such persons only. Individuals responsible for the installation of the equipment described in this user's guide must ensure ;

1) only technically qualified individuals are employed to work on the installation,

2) these qualified individuals must have the accompanying documentation available at all times when working on the installation and are obliged to use this documentation in a consistent manner, and

3) work on, or close to, the installation is prohibited for non-technically qualified individuals

Throughout this user's guide may be found **NOTES, CAUTIONS**, and **WARNINGS and CE-Compliance-Required**. They are defined as follows:

NOTES are general in nature and are intended to emphasise information.

CAUTIONS are to alert personnel to actions that could cause equipment damage, resulting in the equipment becoming unsafe.

WARNINGS serve to make personnel aware of potentially hazardous actions that may result in personal injury or death.

CE-Compliance indicates where a particular application-related safety or EMC requirement is driven by the need for CE-Compliance of the T200 when installed in the system. Customers who do not need CE-Compliance on their machinery may choose not to implement these features.

The T200 controller contains potentially lethal voltages. Extreme caution shall be observed whenever the equipment is in operation. Incorrect installation of the motor or the controller may cause damage to the equipment, serious personal injury or death. Consequently, the instructions in this user's manual, as well as national and local rules and safety regulations, must be complied with.

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2.2 Safety regulations

1. The T200 controller must be disconnected from all power if repair work is to be carried out. Check that the mains supply has been disconnected and that at least 5 minutes has passed, to allow for d.c. bus capacitors to discharge, before removing motor and mains plugs.
2. Correct protective earthing of the equipment must be established, the user must be protected against supply voltage, and the motor must be protected against overload in accordance with applicable national and local regulations.
3. Do not remove the plugs for the motor and mains supply while the T200 controller is connected to mains power. Check that the mains supply has been disconnected and that the necessary time has passed before removing motor and mains plugs.

Warning against unintended start
The installation of safety interlocks, additional control and protection devices must be done in accordance with the relevant local safety requirements. Note that changes made through software can result in the motor starting suddenly.

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2.3 Safety

This user's manual assumes that the user has a basic working knowledge of servo-drive products and the system motion controller. The user should provide the necessary additional training for ALL personnel working within or around the workcell.

NOTE - These safety precautions are guidelines only and are not claimed to be comprehensive. The Moog Brushless Technology products described herein, in conjunction with the system controller, provide the capability for control of remote devices. Typically, these remote devices move at high speeds and exert considerable force. Like all mechanical systems and most industrial equipment, they must be treated with respect by both the machine integrator, user and the operator.

NOTE - This user's guide defines "user" as the responsible person or company and "operator" as a person who starts, stops or monitors workcell operation.

NOTE - This user's guide should be read by all personnel who operate or who work within or near the workcell.

Individuals responsible for the installation of the equipment described in this user's guide must ensure that only technically qualified service personnel are employed to work on the installation.

In the context of these safety instructions, skilled technical personnel means people who are familiar with the product, and have the necessary technical qualifications required for the performance of their functions.

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2.3.1 System Safeguards

a) General Safety Requirements

Users are required to implement safety measures with all equipment, systems and installations into which the T200 Servo-drive are installed. In addition, safeguards must be an integral part of workcell design, installation, operator training and operator procedures where this equipment is used.

The T200 is suitable for use in a circuit capable of delivering not more than 5000 rms symmetrical amperes, 240 volts maximum.

Users are directed to refer to the European Union (EU) Machine Safety Directive: 89/392/EEC (as amended by EU Directives 91/368/EEC, 93/44/EEC and 93/68/EEC) and EU Low Voltage Directive 73/23/EEC (as amended by EU Directive 93/68/EEC) for essential health and safety requirements to be met. Furthermore the requirements of the EU EMC Directive: 89/336/EEC (as amended by EU Directive 92/31/EEC and 93/68/EEC) must be met by all equipment, systems and installations into which the T200 Power Supply and Controllers are installed.

Users are recommended to refer to the latest publications of the European Union (EU) Commission and to local regulations for further information on the requirements of these Directives of the EU.

b) Specific Safety Requirements

The specific safety measures described below are required to be installed by the user into all equipment, systems and installations into which the T200 Series Controllers are installed.

The user is required to provide safety interlocks to prevent unexpected restart during servicing of the T200 Series Controller and any equipment attached to or driven by these units.

The T200 Servo-drives themselves must be installed in enclosures or cabinets that provide a degree of ingress protection against liquids and objects of at least IP54. These enclosures or cabinets must be accessible to technically qualified service or maintenance persons only. All external Regen (Regenerative circuit) resistors used with the T200 must be installed in enclosures which provide a degree of ingress protection against liquids and objects of at least IP22 and which are accessible to technically qualified service or maintenance persons only. Protection against electric shock must be maintained when installing these resistors.

The T200 Servo-drive must be permanently and reliably connected to Earth and all conductive parts in the IP54 rated enclosure or cabinet must be permanently connected to Earth. The impedance between the earth terminal and any accessible part of the enclosure or cabinet shall be less than or equal to 0.1 ohms.

All electrical supply wires and cables to this equipment must be installed in wireways (cable routings) which are smooth and free from sharp edges.

The optional 24V input is intended for use in the secondary of a Class 2 supply. Alternatively it should be fitted with a UL Listed Current limiting type fuse rated 3A on the supply side to the device.

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All external d.c. supply voltages used with the T200 Series Controllers must be derived from a Safety Extra Low Voltage (SELV) supply as defined by standard EN60950. Such SELV voltages do not exceed a value of 60 Vd.c. or 42.4 Va.c. peak under normal conditions and are supplied by circuits which are separated from all hazardous voltage conductors by permitted safety methods such as reinforced insulation.

All external electrical wiring connected to this equipment must be colour coded in accordance with European Standard EN 60204-1 requirements. (Refer Section 2.6 of this manual).

All wires and cables entering and leaving the IP54 rated enclosures or cabinets containing the T200 Power Supply, Controllers and Regen resistor(s) must be protected and anchored in accordance with the requirements of EN 60204-1. (Refer to Section 2.6 of this manual).

A mains circuit breaker must be installed with this equipment and be accessible to the user.

This circuit breaker shall be sized such that it provides adequate r.m.s protection based on primary voltage and power rating (kW) of the T200 system. Surge tolerance and single phase protection should also be considered.

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2.3.2 Equipment Safety

All persons must observe sound safety practices during the operation and testing of all electrically powered equipment.

Prior to first use, power should not be applied to the T200 Servo-drive until all instructions in the Wiring and Installation section of this User's manual have been carried out.

WARNING – You must disconnect the T200 Servo-drive from all voltage supplies (230 Va.c., 120 Va.c., 24 Vd.c.) before servicing.

WARNING - DO NOT remove or replace any assemblies, subassemblies or components with primary power present.

WARNING - Lethal voltages remain present within this equipment when the mains power is removed. It is recommended to refrain from commencing any servicing, maintenance, repair or upgrading of this equipment until at least five minutes after power shutdown. It is further recommended to measure the voltage level at all high voltage terminals before commencing any such activities, to ensure that no lethal voltages are present.

WARNING – The removable plug-in connectors of the T200 Servo-Drives are for ease of wiring installation. These removable plug-in connectors are not suitable for connection or disconnection under power. All connections must be made with power removed.

WARNING - Repair or internal adjustments to the T200 Series Controllers must not be attempted. All faulty items must be returned to Moog Service Centres for maintenance and repair.

WARNING - Entering the workcell when HIGH POWER or PROGRAM RUNNING indicators are ON may result in severe injury.

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WARNING - The equipment described in this user's guide operates at voltage levels which can exceed 400 volts d.c. and/or 230 volts a.c. These levels are a potential source of severe electrical shock. DO NOT remove or replace any assemblies, subassemblies or components with the primary power present. To avoid possible personal injury or equipment damage, always remove power BEFORE attempting repair or upgrade procedures. Wait at least 5 minutes after power shutdown to ensure power supply capacitors have discharged. Then using a voltmeter, check for safe levels across all high voltage power terminals.

Safe-guards should be an integral part of a workcell design, installation, operator training, and operator procedures. A computer controlled system may activate remote devices under program control at times not anticipated by personnel. It is critical that safeguards be in place to prevent personnel from entering the workcell whenever equipment power is present. Moog highly recommends the use of workcell safety features such as light curtains, safety gates or safety floor mats to prevent access to the workcell while power is present. Computer controlled systems have various communication features which may aid the user in constructing system safeguards, including:

- emergency stop circuitry
- binary input and output lines
- spare system-controlled user lines

The emergency power-off circuitry of a computer controlled system is generally capable of switching external power systems, as well as detecting intrusion signals from safety barriers.

All personnel must observe sound safety practices during the operation and testing of all electrically powered equipment. To avoid injury or damage to equipment, always remove power BEFORE attempting ANY repair or upgrade activity.

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2.3.3 Safety Requirements for Cables

User's whose machine installations require CE-Compliance should read Section 2.3.3.

a) Requirements - Conductors and Cables

All cables and conductors used shall be specified as compliant with the requirements of European Standard EN 60204-1 and other known National and International Standards for the environment in which they are installed and for the voltage and current carried.

Conductors and cables shall be specified and selected so as to be suitable for the operating conditions (e.g. voltage, current, protection against electric shock, grouping of cables) and external influences (e.g. ambient temperature, presence of water or corrosive substances, mechanical stress) which can exist.

Wherever possible, insulated conductors and cables which have flame-retardant properties shall be used.

Where insulated conductors and cables can constitute a fire hazard due to the propagation of a fire or the emission of toxic or corrosive fumes (e.g. PVC), guidance from the cable supplier should be sought. In particular it is important to maintain the integrity of circuits having a safety function (e.g. emergency stop) for as long as possible under these conditions.

The mechanical strength and thickness of the insulation shall be such that the insulation cannot be damaged in operation or during laying, especially for cables pulled into ducts.

The voltage drop on cables and conductors shall not exceed 5% of the nominal voltage. The current carrying capacity of the conductors and cables is determined by both:

- the maximum allowable conductor temperature under the highest possible steady state current under normal conditions; and
- the ultimate allowable short-time conductor temperature under short circuit conditions.

b) Wiring Practices - Connections and routing

All connections, especially those of the protective bonding circuit, shall be secured against accidental loosening.

c) Wiring Practices - Conductor and cable runs

Conductors and cables shall be run from terminal to terminal without splices or intervening joints

Where it is necessary to connect and disconnect cables and cable assemblies, sufficient extra length shall be provided for this purpose.

The terminations of multicore cables shall be adequately supported where undue strain can be exerted on the terminations of the conductors.

Wherever possible, the protective conductor shall be placed close to the associated live conductors in order to decrease the impedance of the loop.

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d) Wiring Practices - Conductors of different circuits

Subject to the constraints for EMC suppression given in Sections 2.3 and Section 3 of this User's manual, conductors of different circuits may be laid side by side, may occupy the same duct (e.g. conduit, cable trunking system), or may be in the same multicore cable, provided that the arrangement does not impair the proper functioning of the respective circuits. Where these circuits operate at different voltages, the conductors shall be either separated by suitable barriers or insulated for the highest voltage to which any conductor within the same duct can be subjected.

Circuits which are not switched off by the supply disconnecting device (circuit breaker) shall be either physically separated from other wiring or distinguished by colour (or both) so that they can be identified as being live when the supply disconnecting device is in the OFF or OPEN position.

e) Wiring Practices - Identification of conductors

For safety reasons, the colour Green or the colour Yellow shall not be used where there is a possibility of confusion with the bicolour combination GREEN-AND- YELLOW.

Colour identification using combinations of colours may be used provided there can be no confusion and that GREEN or YELLOW is not used, except in the bicolour combination GREEN- AND-YELLOW.

f) Wiring Practices - Identification of the protective conductor

The protective conductor shall be readily distinguishable by shape, location, marking or colour. When identification is by colour alone, the bicolour combination GREEN-AND-YELLOW shall be used throughout the length of the conductor. This colour identification is strictly reserved for the protective conductor.

For insulated conductors, the bicolour combination GREEN-AND-YELLOW shall be such that on any 15mm length, one of the colours covers at least 30% and not more than 70% of the surface of the conductor, the other colour covering the remainder of the surface.

Where the protective conductor can be easily identified by its shape, position or construction (e.g. braided conductor), or where the insulated conductor is not readily accessible, colour coding throughout its length is not necessary but the ends or accessible positions shall be clearly identified by the graphical symbol or by the bicolour combination GREEN-AND-YELLOW.

g) Wiring Practices - Identification of the neutral conductor

Where a circuit includes a neutral conductor identified by colour, the colour shall be LIGHT BLUE. LIGHT BLUE shall not be used for identifying any other conductor where confusion is possible.

In the absence of a neutral conductor, a LIGHT BLUE conductor may be used for other purposes except for use as a protective conductor.

Where identification by colour is used, bare conductors used as neutral conductors shall be either coloured by a LIGHT BLUE stripe, 15 mm to 100 mm wide, in each compartment or unit or at each accessible position, or coloured LIGHT BLUE throughout their length.

h) Wiring Practices - Wiring inside enclosures

Panel conductors shall be supported where necessary to keep them in place. Non-metallic channels or conduits shall be permitted only when made with a flame-retardant insulating material. Where possible earthed shielded metal cable ducting should be used to minimise EMC noise coupling.

It is recommended that electrical equipment mounted inside the enclosures be designed and constructed in such a way as to permit modification of the wiring from the front of the enclosure. Where this is not possible and control devices are connected from the rear of the enclosure, access doors or swing-out panels shall be provided.

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Connections to devices mounted on doors or to other movable parts shall be made using flexible conductors in accordance with European standard EN 60204-1, to allow for the frequent movement of the part. The conductors shall be anchored to the fixed part and the movable part independently of the electrical connections.

Conductors and cables that do not run in ducts shall be adequately supported.

Terminal blocks or attachment plug/socket combinations shall be used for control wiring that extends beyond the enclosure.

Power cables and cables of measuring circuits may be directly connected to the terminals of the devices for which the connections were intended.

i) Wiring Practices - Wiring outside enclosures

The means of introduction of cables or ducts with their individual glands, bushings, etc., into an enclosure shall ensure that the degree of protection is not reduced.

Conductors and their connections external to the electrical equipment IP54 enclosures shall be installed in suitable ducts (i.e. conduit or cable trunking systems) as described in Section 2.3.4, except for suitably protected cables, which may be installed without enclosing ducts and with or without the use of open cable trays or cable support means.

Fittings used with ducts or multi-conductor cable shall be suitable for the physical environment.

Flexible conduit or flexible multi-conductor cable shall be used where it is necessary to employ flexible connections to pendant push-button stations. The weight of pendant stations shall be supported by means other than the flexible conduit or the flexible multi-conductor cable, except where the conduit or cable is specifically designed for that purpose.

Flexible conduit or flexible multi-conductor cable shall be used for connections involving small or infrequent movements. They shall also be permitted to complete the connection to normally stationary motors, to position switches, and to other externally mounted devices.

Connections to frequently moving parts shall be made with conductors suitable for flexing service in accordance with European standard EN 60204-1. Flexible cable and flexible conduit shall be so installed as to avoid excessive flexing and straining particularly at the fittings.

Cables subject to movement shall be supported in such a way that there is no mechanical strain on the connection points nor any sharp bending. The loop shall have sufficient length to provide for a bending radius of the cable of at least ten times its outside diameter.

Where cables subject to movement are close to moving parts, precautions shall be taken so that a space of at least 25mm shall be maintained between the moving parts and the cables. Where this distance is not practicable, fixed barriers shall be provided between the cables and the moving parts.

The cable sheath shall be resistant to the normal wear which can be expected from movement, and to the effects of atmospheric contaminants (e.g. oil, water, coolants, dust).

Where flexible conduit is adjacent to moving parts, the construction and supporting means shall prevent damage to the flexible conduit or cable under all conditions of operation.

Flexible metal conduit shall not be used for rapid or frequent movements, except when specifically designed for that purpose.

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j) Wiring Practices - Ducts, connection and junction boxes

All sharp edges, flash, burrs, rough surfaces, or threads, with which the insulation of the conductors may come in contact, shall be removed from ducts and fittings. Where necessary, additional protection consisting of a flame-retardant, oil-resistant insulating material shall be provided to protect conductor insulation.

Ducts and cable trays shall be rigidly supported and positioned at a sufficient distance from the moving parts and in such a manner so as to minimise the possibility of damage or wear.

Cable trunking systems external to enclosures shall be rigidly supported and clear of all moving or contaminating portions of the machine or equipment into which they are installed.

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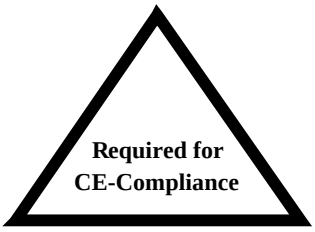
2.3.4 EMC requirements for cables



User's whose machine installations require for CE-Compliance should read Section 2.3.4.

Avoid close parallel routing of signal cables and power cables. Always use the minimum length of cable necessary and install all cables in a fixed routing.

Data signal cables, motor power and resolver/signal cables, regen resistor cables and power input cables shall have segregated routings. Where cable routings must intersect, it is recommended that they intersect at an angle of 90 degrees, to minimise EMC noise coupling.

Where signal and power cables must run in parallel it is recommended that these cables are separated by at least 20 cm. Where possible cables shall be routed in earthed shielded cable ducting, to minimise electromagnetic noise coupling.

Use shielded cable to connect the external regen resistor (if installed) to the T200 power supply. The length of this cable shall be as short as possible. The shields of these voltage supply cables shall be earthed to Chassis Earth using the optional EMC kit or the panel earth bar. Alternatively, if the cable is required to pass through an enclosure panel earthed to Chassis Earth, the shield may be earthed to the panel by use of a 360 degree metal cable gland. (Refer to Section 2.3 and Section 3.13 for safety and other relevant installation requirements for Regen resistors).

Cables supplying external d.c. supply voltages to the T200 Servo-drive (For example, the 24 Vd.c. supply) must be as short as possible. The supply wires shall be twisted together or alternatively shielded cable shall be used.

Cables connecting the 325 V d.c. bus from the T200 Servo-drives must be as short as possible. The supply wires shall be twisted together.

Motor power cables must be shielded with the cable shield securely connected to Chassis Earth at both ends of the cable. At the T200 end of the cable the shield shall be earthed to Chassis Earth using the optional EMC kit or the panel earth bar.

Motor resolver/signal cables must be shielded with the cable shield securely connected to Chassis Earth at both ends of the cable.

Signal cables must be shielded with the cable shield securely connected to make a good HF earth bond to Chassis Earth at both ends of the cable.

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2.4 Electromagnetic Compatibility (EMC)

User's whose machine installations are intended for CE-Compliance should read Section 2.4. Otherwise reading of Section 2.4 is not required.

The T200 Servo-drive are system components which must be installed in a correct manner to ensure that all electromagnetic compatibility (EMC) requirements are met. The requirements of European Union (EU) EMC Directive: 89/336/EEC (as amended by EU Directives 92/31/EEC and 93/68/EEC) must be met by all equipment, systems and installations into which the T200 Servo-drive are installed.

For further information on the requirements of EU EMC Directive the user is recommended to refer to the latest publications of the EU Commission and to local regulations.

The T200 Servo-drive have been tested for compliance with the requirements of the EU EMC Directive in so far as they can be regarded as single functional units. The T200 Power Supply and Controller have been tested in typical configurations and it has been found that these configurations meet the essential requirements of the EU EMC Directive. Details of these configurations are given in Appendix A.

The EMC standards applied were as follows:

- EMC Emission Standard EN 55011:1991, Limits and methods of measurement of radio disturbance characteristics of industrial, scientific and medical (ISM) radio-frequency equipment. (Group 1, Class A).
- EMC Immunity standard EN 50082-2:1995, Electromagnetic compatibility Generic Immunity Standard Part 2: Industrial Environment.

Both these standards are published by CENELEC, the European Committee for Electrotechnical Standardisation, Brussels.

2.4.1 Specific Electromagnetic Compatibility (EMC) Requirements:

The EMC measures outlined below are required to be installed by the user into all equipment, systems and installations into which the T200 are installed. Further details are given in the referenced sections of this User's Guide.

The T200 Servo-drive must be installed by mounting on a panel in a manner that ensures that EMC earthing requirements are met. (Refer Section 3 of this User's Guide).

An optional EMC kit is available to facilitate earthing of cable shields prior to entering the T200. Cable shields must be bonded to either the panel earthing bar or the optional EMC kit.

For safety reasons the T200 Servo-drive, and the panel on which they are mounted must be installed in enclosures or cabinets which provide a degree of ingress protection against liquids and objects of at least IP54. These enclosures or cabinets must be accessible to technically qualified service or maintenance persons only.

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For Electrostatic Discharge (ESD) reasons all service or maintenance persons must ground themselves to the chassis of the equipment when performing service functions inside the IP54 rated enclosure or cabinet in which the T200 Servo-drive are installed.

All external d.c. supply voltages used with the T200 must be supplied from power supplies which are compliant with the requirements of the EU EMC Directive. All other equipment that is connected to the T200 must be compliant with the EU EMC Directive.

For single phase power applications an a.c. power input line filter is required to be installed by the user in the a.c. mains power input supply lines to the T200 (not required for 120Va.c. control backup power input). For further details see Appendix A. For three phase power applications an isolation transformer must be used for EMC compliance.

Shielded cable is required to be installed by the user for many external user cable connections to the T200. Details of areas where shielded cable must be installed and details of earthing arrangements which must be implemented for the shields of such cables are given in Section 2.3 and throughout Section 3 of this User's Guide. Installation requirements for external Regen (Regeneration Circuit) resistors are given in Section 3.13 of this User'Guide. Common Mode noise suppression ferrites must be used at both ends of cables connected to the Axis I/O Connector (J1) and optional Extended I/O Card connector. In CAN (Controller Area Network) applications common mode noise suppression ferrites must be used on the cables of the 24Vd.c. Control Logic Supply and CAN-IN terminal at the point of connection to the T200.

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SECTION 3: WIRING AND INSTALLATION

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This section covers the installation, wiring and cabling of the Moog T200 Servo-drive series. A pictorial diagram of a single-axis system, with typical components included, is shown in Figure 3.1. Users are directed to read Section 2, Safety Instructions, before proceeding with wiring and installation.

WARNING – You must disconnect the T200 Servo-drive from all voltage supplies (230 Va.c., 120 Va.c., 24 Vd.c.) before servicing.

WARNING - This equipment must be permanently and reliably connected to Earth and all conductive parts in the IP54 rated enclosure in which the T200 Series Servo-drive is installed must be reliably connected to Protective Earth. A Protective Earth connection must come directly from an approved a.c. mains network. Stranded copper -wire, is recommended to carry the earth.
FAILURE TO PROVIDE AN ADEQUATE EARTH MAY CAUSE SERIOUS PERSONAL INJURY AND EQUIPMENT MALFUNCTION.

3.1 System Components

The following components are required to build a Moog brushless motor velocity or torque digital control system (refer to Figure 3.1). Section 6, Functional Overview of the T200, provides a more thorough description of the operation of the T200. All components besides the T200, EMC-Brackets, G4XX motor, motor and other accessory cabling, and the Hand Held Terminal are supplied by the user.

All T200 models encorporate **internal overload protection for the motor load** and are not required to be used with external or remote overload protection. Details of this protection are given in Section 6 of this manual. The associated software commands are given in Sections 7 and 8.

3.1.1 a.c. Mains Power Interface

The T200-310/410/510 may be connected in either single-phase or three-phase mode. The T200 a.c. mains input power ratings are given in Table 3.1, for single phase and three-phase mode.

The T200-310/410/510 may be connected directly to single phase a.c. mains supply networks. Note, however, that it operates at lower input power ratings, when coupled to single-phase a.c. mains.

In three-phase mode, where the T200 is capable of higher input power, a user supplied step-down transformer is usually required, to drop the a.c. mains voltage to 230Va.c.. This transformer may also provide electrical isolation of the T200 from the neutral point of the three phase mains, as well as limit the inrush current from the mains on power-on.

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3.1.1.1 Single-Phase Mains Connection

The T200-310/410/510 can operate with single phase a.c. mains voltage sources from 120Va.c. to 230Va.c.. Note that the input power must be linearly de-rated for mains voltages lower than 230Va.c., as shown in Table 3.1. The T200 does **not** require an input isolation transformer for single-phase operation, for Low Voltage Directive Compliance.

- Table 3.1 gives an overview of the T200 in single-phase operation (230 Va.c. and 120Va.c.).

Servo-Drive Model	Three Phase 230Va.c. Rating		Single Phase 230Va.c. rating		Single Phase 120Va.c. rating	
	Rated Continuous Input Power	***Rated Continuous DC Bus Output Power***	***Rated Continuous Input Power***	***Rated Continuous DC Bus Output Power***	***Rated Continuous Input Power***	***Rated Continuous DC Bus Output Power***
T200-310	7.5kW	6.5kW	2.5kW	2.5kW	1.2kW	1.2kW
T200-410	7.5kW	6.5kW	2.5kW	2.5kW	1.2kW	1.2kW
T200-510	7.5kW	6.5kW	2.5kW	2.5kW	1.2kW	1.2kW
T200-610	15.0kW	6.5kW	Single phase operation not available for T200-610 and T200-710			
T200-710	15.0kW	6.5kW				

Table 3.1: T200 Input Power Ratings versus Single and Three Phase Mains Voltage Level

3.1.1.2 Three Phase Mains Connection

For three-phase operation it is usually required that a voltage-matching transformer is installed as part of the total system. The transformer serves the following functions:

1. Matching the mains supply line voltage to the required power supply input voltage.
2. Limiting available short circuit fault current to be within the interrupting rating of the a.c. input circuit breaker.

NOTE - The T200 is designed to allow direct a.c. off-line operation from a 230 Va.c. (Vr.m.s) 50/60 Hz three phase source capable of delivering not more than 5000 RMS (r.m.s.) symmetrical amperes. A 3 Phase step down transformer is typically used to drop the size of the a.c. mains voltage to 230Va.c., though the step down transformer is not needed if the a.c. mains magnitude is already 230Va.c.. The transformer should be chosen by the user such that its KVA rating covers the maximum power requirement of the application. If in doubt as to the application power requirements, a 7.5 KVA minimum rating is recommended for use with a T200-310, -410 or -510, and a 15 KVA minimum rating is recommended for use with a T200-610 or -710.

Transformers should be installed in a clean, dry, enclosed environment. Maximum ambient temperature should not exceed 60°C (140°F).

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3.1.2 A.C. Input Circuit Breaker - (User Supplied)

It is recommended that an a.c. mains Circuit Breaker is used as a protective device.

A single or three phase automatic circuit breaker will ensure that all phases are interrupted in the event of a fault condition. After a power loss to the servo-drive, the motor will continue running until it's stored energy is dissipated through friction alone, or will be stopped by a motor-equipped brake if a brake is available.

It is also recommended to install a contactor rated for the T200 input power (see Table 3.1: T200 Input Power Ratings versus Single and Three Phase Mains Voltage Level) between the output of the transformer and the input of the T200 (refer to Figure 3.1). This contactor should be controlled directly by user supplied Emergency Stop Buttons and other series connected safety switches to remove a.c. input power in any situation affecting personnel safety.

WARNING - The supply disconnecting device (circuit breaker) must be switched to the OFF position before any service or maintenance activity is commenced.

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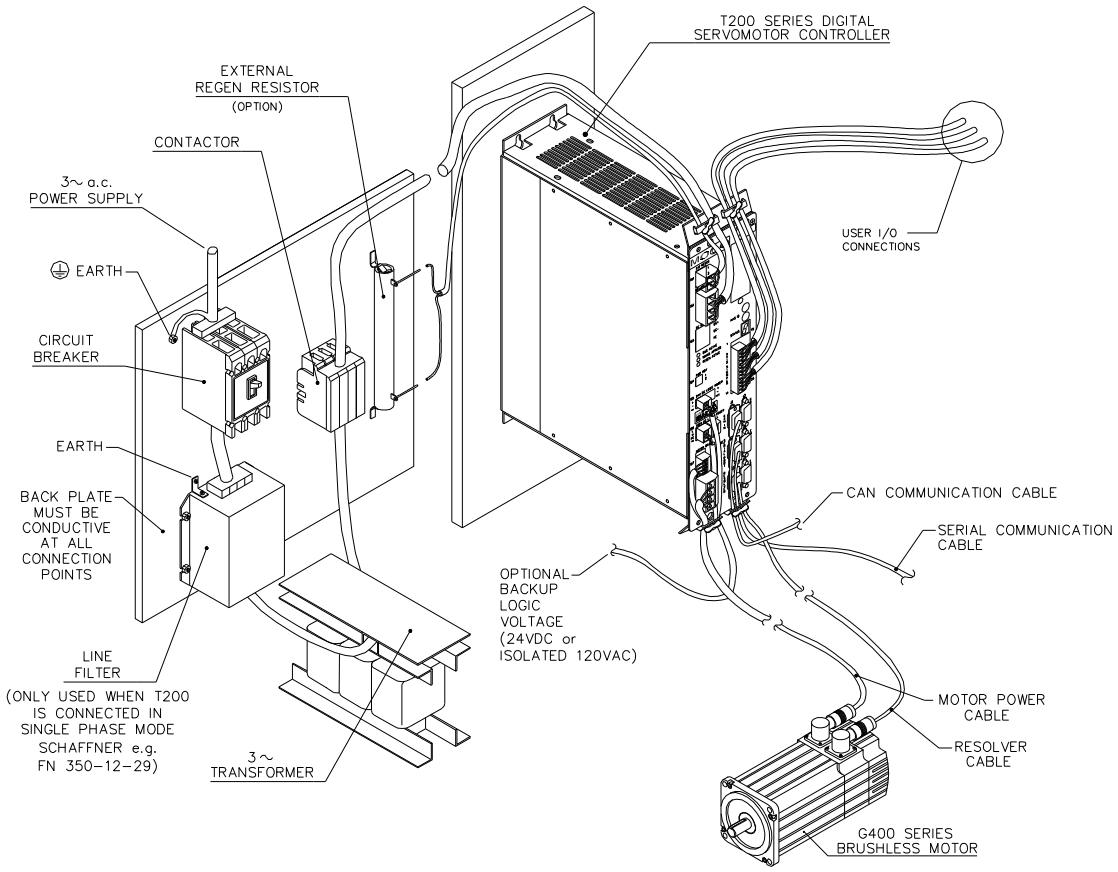

Figure 3.1:- Typical T200 System Components

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3.1.3 Serial Set-up Terminal (User-Supplied)

An RS-232 interface should be established for individual servo-drive communications, using a user supplied IBM compatible service computer (PC) or a Hand Held Terminal (HHT). The IBM PC can run either a Terminal Emulation program (e.g. Windows 95 HyperTerminal) or Moog's WinDrive Windows-based user-interface program.

The hand held service terminal or personal computer are service engineer tools only and must be installed so that use of the key sequences which allow control of the machine functions is accessible to authorised qualified service personnel only. All such hand held service terminals or service set-up computers must be CE -marked as compliant with the EU EMC Directive.

For multi-drop communications of up to thirty (30) T200 Servo-drives, an RS-485 interface should be used. See Section 3.18.2.2 RS485 Adaptor for Conversion of RS232 to RS485, for further information.

3.1.4 Control-Backup Power Input (User Supplied)

The T200 requires a control power source to supply backup-power for the control electronics. This control-backup power is useful where the user requires that the T200 does not loose absolute position data or status information when a.c. mains power is removed from the T200. There are two possibilities for this control-backup supply

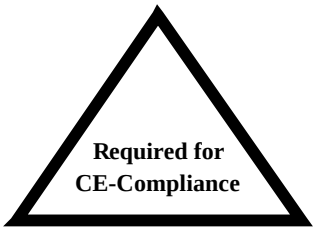
- 24Vd.c. Control-Backup Power Supply **OR**
- 120Va.c. Control-Backup Mains Supply

The user is directed to the local Moog sales office or authorised distributor for a recommended list of these control power source devices.

3.1.4.1 24 Vd.c. Control-Backup Power Supply

The 24 Vd.c. control power option allows high voltage motor power to be removed from a T200 Series Servo-drive without losing control power.

The acceptable voltage range for this supply is 18 to 36 Vd.c. with a minimum current rating of 2.0 Ad.c. per T200 Series Servo-drive connected. A low cost unregulated d.c. supply is adequate. However the instantaneous voltage should never drop below 17.5Vd.c., (including ripple).



NOTE - The 24 V d.c. power supply must be compliant with the requirements of the EU EMC Directive. The 24 V d.c. voltage output from the power supply must be Safety Extra Low Voltage (SELV - as defined by European standard EN 60950).

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3.1.4.2 120 V a.c. Control-Backup Power Supply

The 120V a.c. Power Supply allows high voltage motor power to be removed from the T200 Series Servo-drive without losing control power.

The acceptable voltage range for this supply is 120 V a.c. +10/-15%, with a minimum current rating of 0.3 A a.c. per T200 Servo-drive connected.

Caution - The 120Va.c. backup must be isolated from the T200 a.c. mains input (in both of the cases where the T200 a.c. mains connection is 3 phase or single phase).

3.1.5 Note on cases where the user does not need to use a Control-Backup Power-Supply

The T200 can generate control power from its internal high voltage D.C. Bus, **if** that internal high voltage is greater than 250Vd.c.

- The critical mains input voltage level, above which logic backup power can be drawn from the ac mains, is 170Va.c. Below this voltage level, a separate 24V DC or 120Va.c. backup power supply must be used.
- If 230Va.c. single or three phase mains is supplied directly to the T200, then the T200 can operate without a control-backup power supply. It will however lose absolute position information when the a.c. mains power is removed.
- If 120Va.c. mains is used to supply the D.C. Bus, then the internal high voltage is not sufficient to generate control power. In this case, the user must connect either a backup 120Va.c. isolated mains power source to the T200's 120Va.c. control-backup input, OR connect a backup 24Vd.c. power source to the T200's 24Vd.c. control-backup input.

3.1.6 Brushless Servo motors

The T200 series Servo-drive is compatible with the Moog G4XX and G3XX range of brushless servo motors.

The G4XX series brushless motors are offered in five frame sizes (see Section 4 for an overview of the motor range). Motors are also available with an optional static holding brake.

Normal connection to the motor requires two cables:- a power and a signal cable. The power cable provides three phase stator power, protective earth and brake connections. The signal cable carries position transducer feedback signals and motor temperature detection connections.

3.1.6.1 Brushless Motor Brake 24V Power Supply

Note that the motor brake requires a 24V ±15% supply for release. This should be rated to cover at least twice the sums of the rated currents of all brakes connected (see Section 4.5.7). Moog recommends that, if long (>5m) motor power cable runs are used in the application, that a separate 24V ±15% power source is used for the brakes.

3.1.7 Heatsinks and Climatic Control

The need for air conditioning will depend on the duty cycle of the system and the surrounding ambient temperature. The maximum allowable ambient temperature is 55°C (131°F). The humidity range is 5-95% non-condensing.

All T200 Servo-drives incorporate internal cooling fans and integral heat sinks. Other than controlling ambient conditions, additional heat sinking is not required.

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3.1.8 Mating Connectors, Cables and Wiring

Moog can provide the necessary cabling for interconnect of the motor to the T200. See Section 3.14 for details. Moog also provides the following accessory cabling for interconnection of individual T200's:-

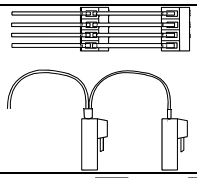
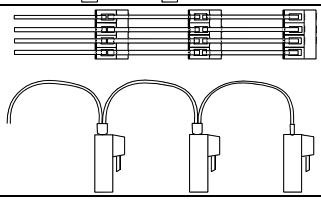
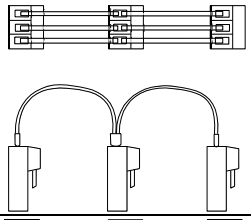
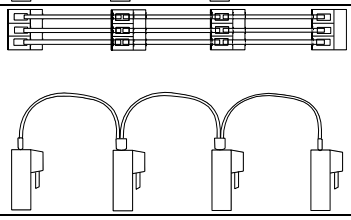
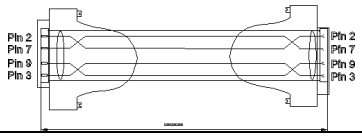
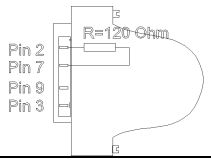
Function	Description	Length between Blocks	Overview Diagram	Moog Part Number
3-Axis System T200-3/4/510 AC Mains Input Connectors	Two AC Mains Blocks provided. The User must provide the AC Mains Input Block for the first T200, as well as wire the AC Mains input.	150mm		C08455-003
4-Axis System T200-3/4/510 AC Mains Input Connectors	Three AC Mains Blocks provided. The User must provide the AC Mains Input Block for the first T200, as well as wire the AC Mains input.	150mm		C08455-004
3-Axis System T200-3/4/510 DC Bus Bridge Connectors	The user may interconnect the DC-Bus amongst 3 T200 units for shared DC Bus power and regeneration capability	150mm		C08454-003
4-Axis System T200-3/4/510 DC Bus Bridge Connectors	The user may interconnect the DC-Bus amongst 4 T200 units for shared DC Bus power and regeneration capability	150mm		C08454-004
CAN to CAN Connector	Connects CAN fieldbus daisychain from T200 unit to the next T200 unit.	180mm		C08450-001
CAN Termination Connector	Terminates the CAN fieldbus with a 120Ohm connector			C08449-002

Table 3.2: T200 Accessory Cabling

All other cabling is user supplied.

3.1.9 Option Cards

The T200 incorporates an EF (extended functionality) slot for option cards, allowing for future system expansion/enhancement. Contact Moog Sales Outlets for further information regarding option cards.

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3.2 Equipment Mounting

Figures 3.2 to 3.7 show the mechanical dimensions of the T200 chassis, as well as required clearances for cabling etc.. The T200 is designed to be panel or cabinet mounted. The T200 must be mounted in a vertical orientation. The T200 must be panel mounted within an enclosure or cabinet which provides a degree of ingress protection against liquids and objects of at least IP54. Such enclosures or cabinets must be accessible to technically qualified service or maintenance persons only. It is recommended that the cabinet be ventilated using filtered or conditioned air, free of corrosive or electrically conductive contaminants. The accumulation of dust, dirt, etc. on the equipment must be avoided. A minimum clearance of 40mm above and below the servo-drive is recommended for the T200-3, T200-4 and T200-5 models, and a minimum clearance of 60mm above and below the servo-drive is recommended for the T200-6 and T200-7 models. If any of the T200 units is mounted in a closed cabinet, allow 60mm clearance at the front.

The T200 must be permanently and reliably connected to Earth and all conductive parts in the IP54 rated enclosure or cabinet must be permanently connected to Earth. The impedance between the earth terminal and any accessible part of the enclosure or cabinet should be less than or equal to 0.1 Ω.

NOTE - The T200 Series Servo-drives are system components that must be installed in the correct manner to ensure that all electromagnetic compatibility (EMC) requirements are met. (Refer to Section 2 of this User's Guide).

The T200 must be mounted on a panel with a flat solid surface in a manner that ensures that EMC earthing requirements are met.

There must be a clean flat conductive surface at all of the mounting points. Remove paint or other insulating materials and provide conductive corrosion protection at the mounting points. It is important that there is good high-frequency bonding between the panel and the T200 Servo-drive. Conductive hex socket head bolts (metric M5 or Imperial #10) with conductive locking washers should be used.

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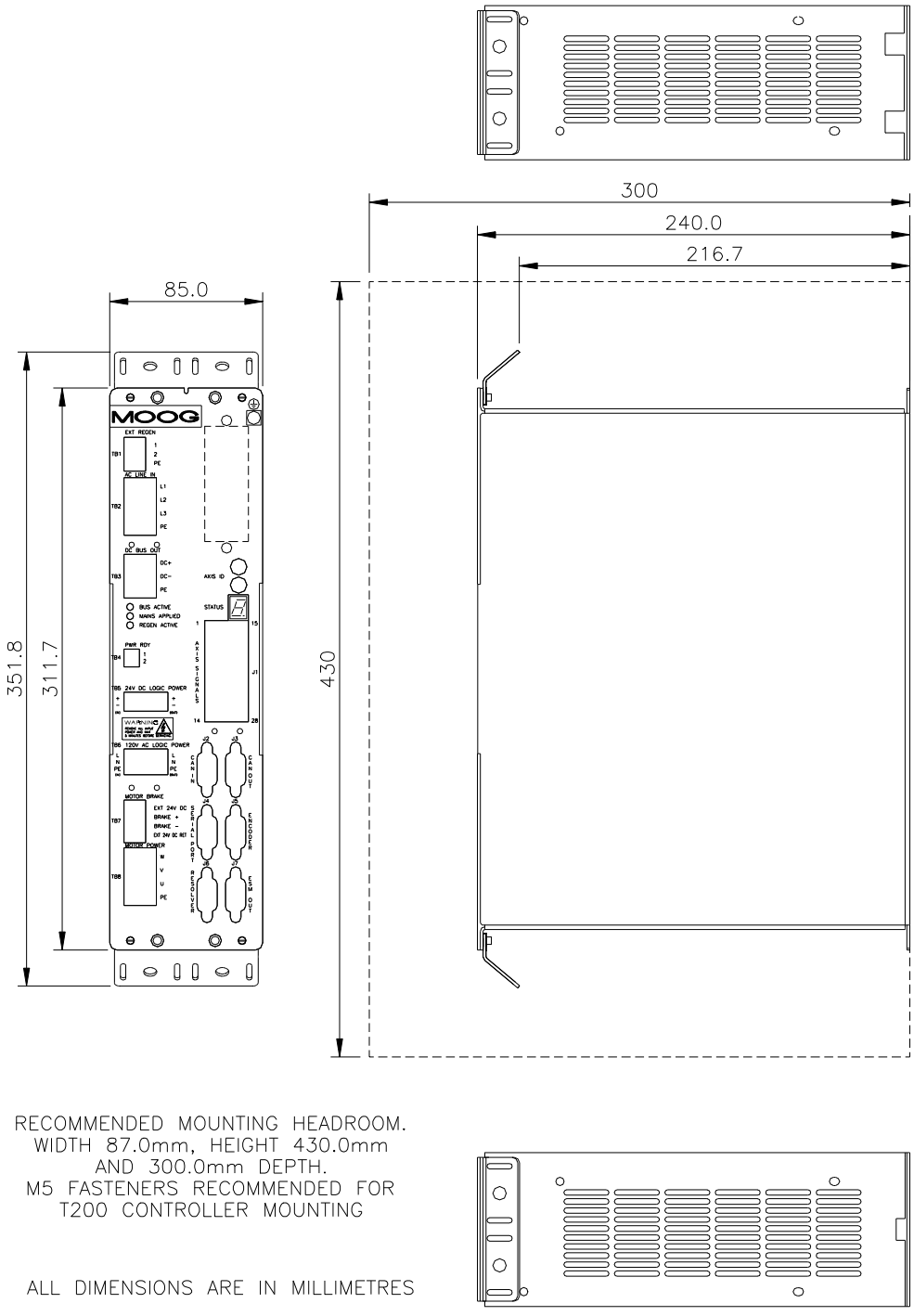

Figure 3.2:- T200-3/4/5 Mechanical Mounting

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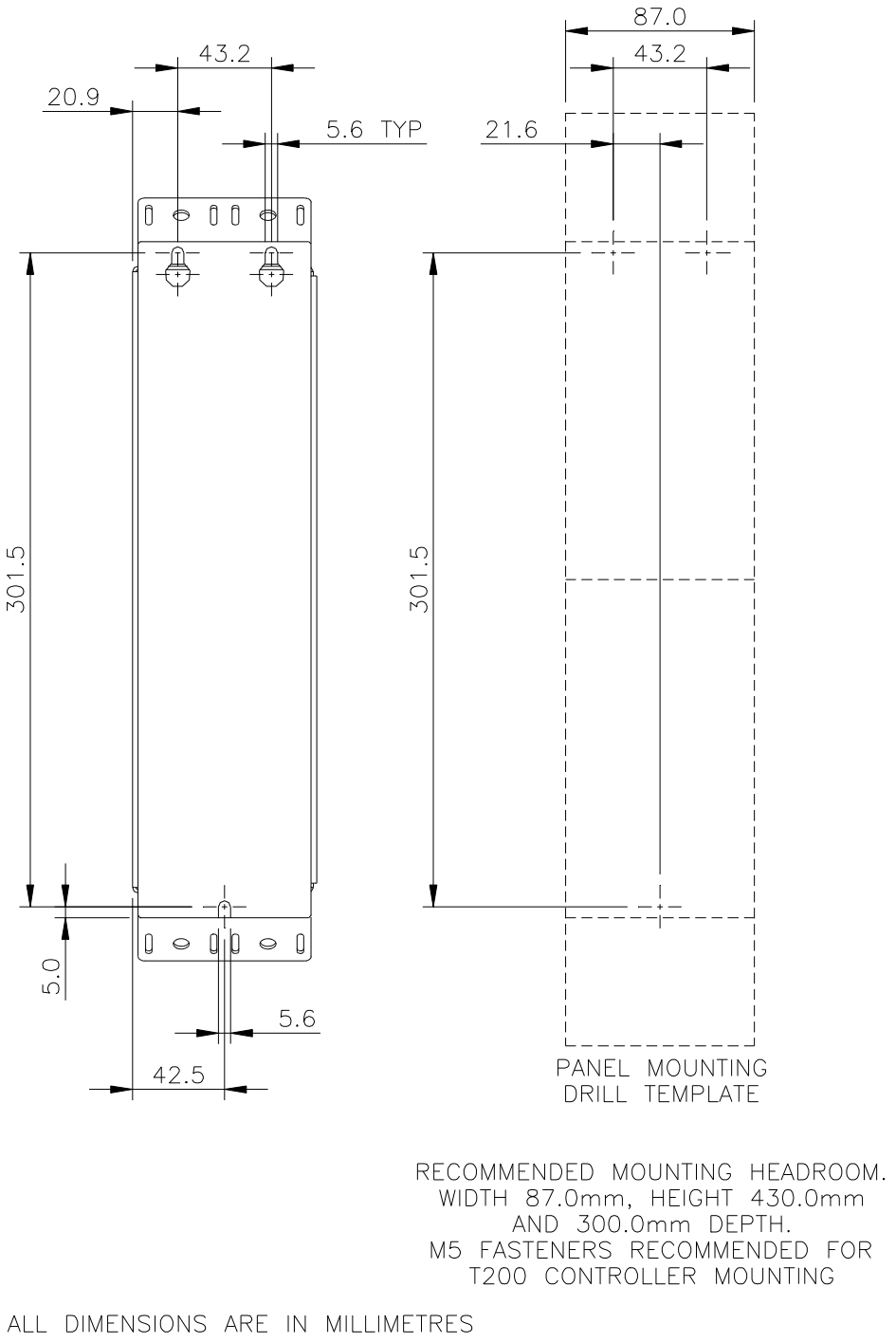

Figure 3.3:- T200-3/4/5 Mechanical Dimensions

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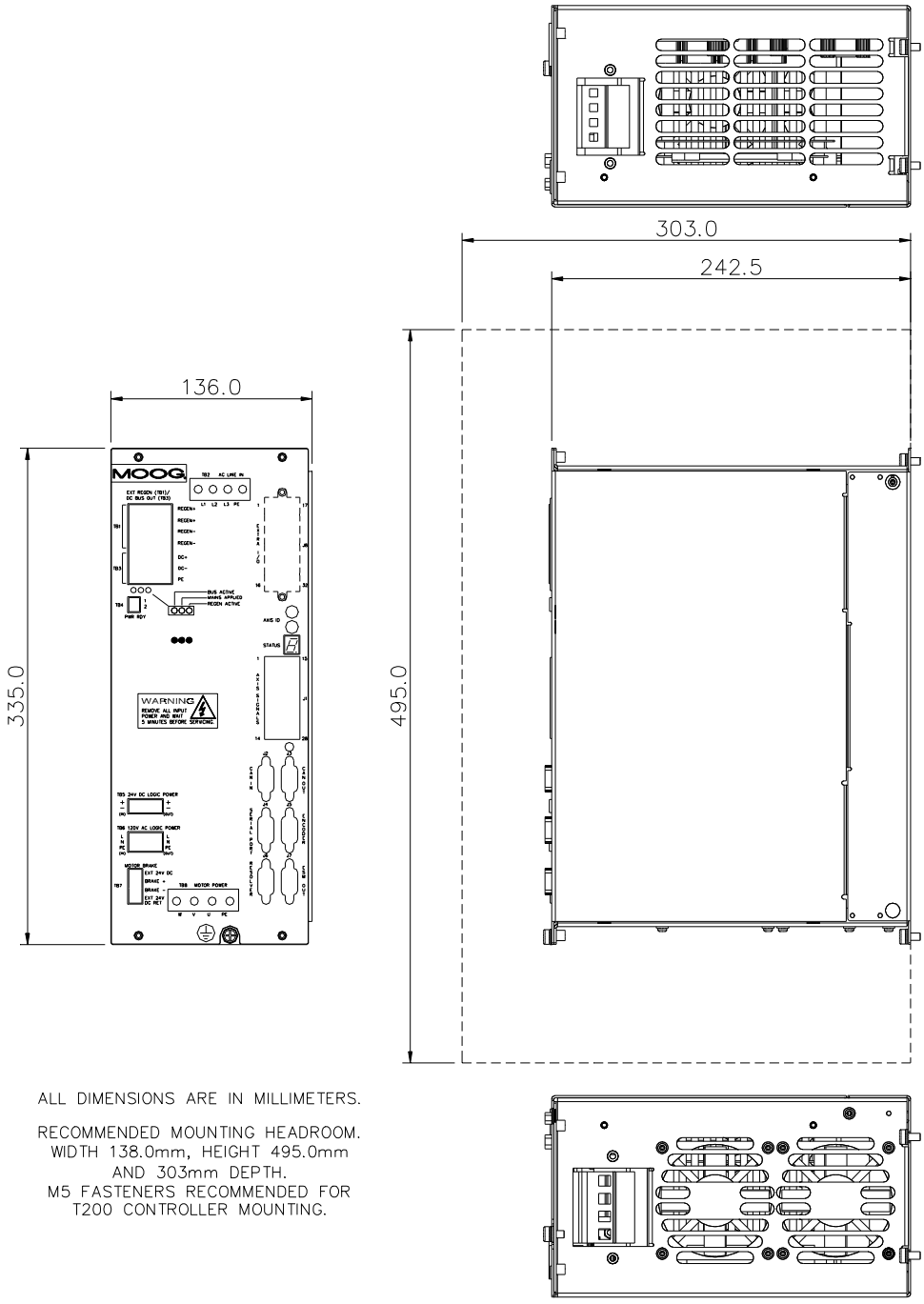

Figure 3.4:- T200-610 Mechanical Mounting

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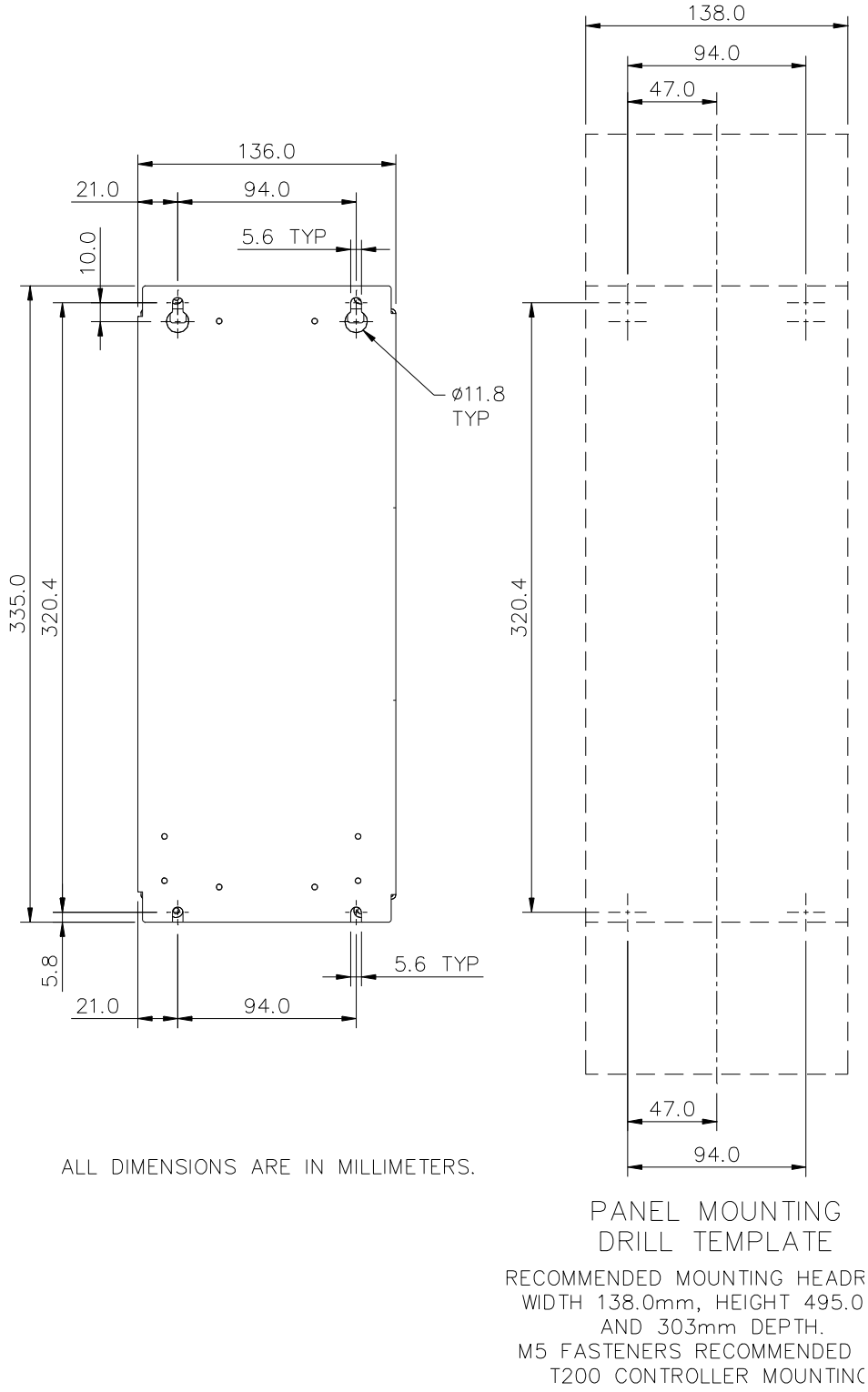

Figure 3.5:- T200-610 Mechanical Dimensions

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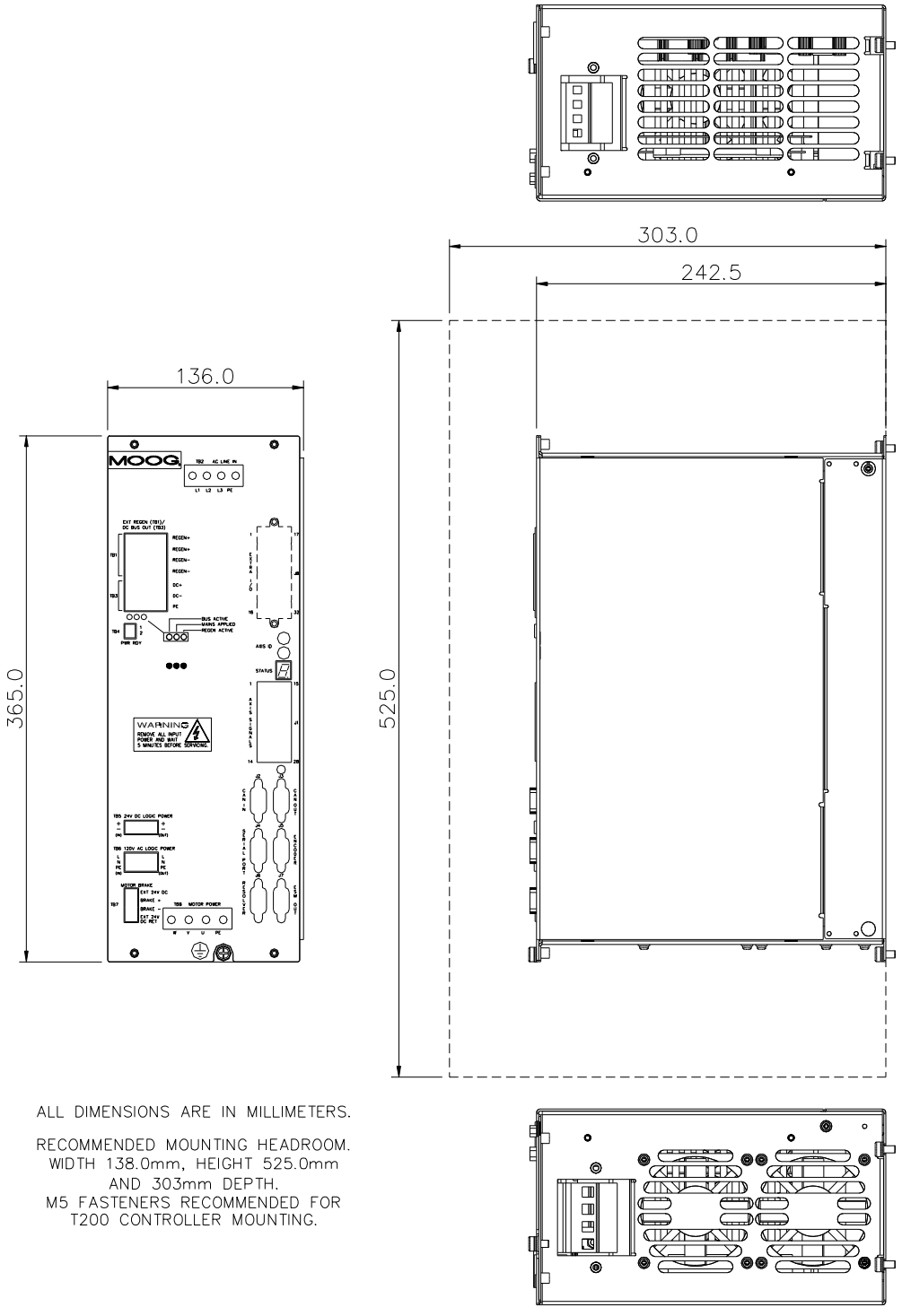

Figure 3.6:- T200-710 Mechanical Mounting

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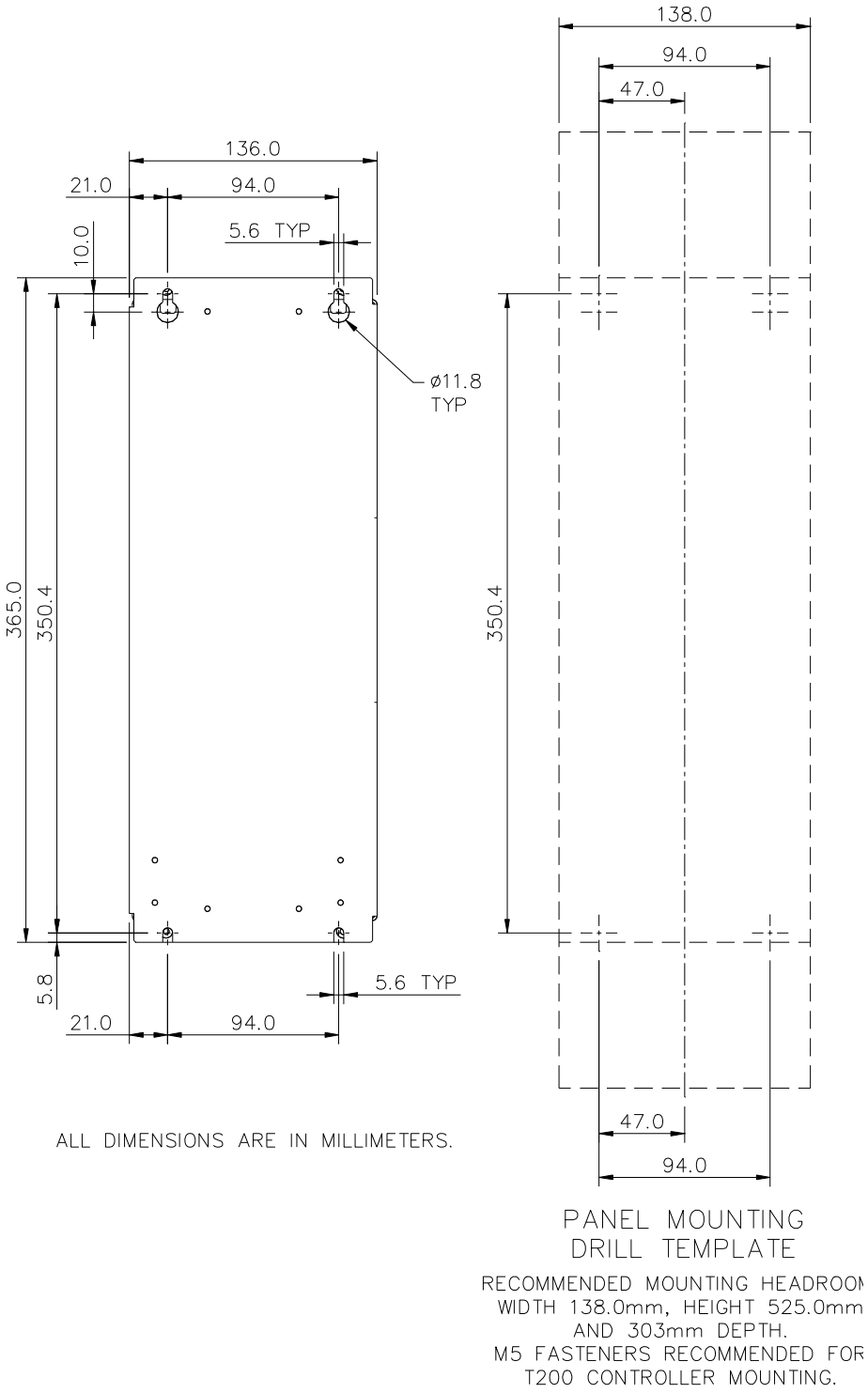

Figure 3.7:- T200-710 Mechanical Dimensions

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3.2.1 CE Items for Mechanical Installation

Additional electromagnetic compatibility (EMC) measures must be installed on equipment associated with the T200 Servo-drive. The following measures must be implemented:

- All external Regen (Regenerative circuit) resistors used with the T200 must be installed in enclosures which provide a degree of ingress protection against liquids and objects of at least IP54 and which are accessible to technically qualified service or maintenance persons only. Protection against electric shock must be maintained when installing these resistors.
- Use shielded cable to connect the external regen resistor (if installed) to the T200 power supply. The length of this cable should be as short as possible. The shields of these cables should be earthed to Chassis Earth using the optional EMC Bracket kit or the panel earth bar. Alternatively, if the cable is required to pass through an enclosure panel earthed to Chassis Earth, the shield may be earthed to the panel by use of a 360 degree metal cable gland.
- Cables supplying external d.c. supply voltages to the T200 Series Servo-drives (for example, the 24 Vd.c. supply) must be as short as possible. The supply wires should be twisted together or alternatively shielded cable should be used.
- Cables connecting the 325V D.C. Bus from the T200 Power Supply to other T200 Servo-drives must be as short as possible. The supply wires should be twisted together where possible or shielded cables should be used.
- Motor power cables must be shielded with the cable shield securely connected to Chassis Earth at both ends of the cable. At the T200 Servo-drive end of the cable, the shield should be earthed using the optional EMC Bracket kit.
- Motor resolver/signal cables must be shielded with the cable shield securely connected to Chassis Earth at both ends of the cable.
- Signal cables must be shielded with the cable shield securely connected to make a good HF earth bond to Chassis Earth at both ends of the cable.

Further details for the correct installation and shielding of cables and conductors are given in Section 2.

CAUTION - Enclosure or cabinet temperature control is critical for performance, reliability and life of electrical components. Maintaining a uniform temperature (check for hot spots) within the specified values for the equipment will prevent premature failure due to temperature stress.

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3.3 Power Dissipation

To calculate cabinet cooling requirements, Table 3.3 provides approximate equipment power dissipation values. If the application employs regeneration, be sure to add the regen resistor power dissipation to the numbers quoted in Table 3.3 below, (use the continuous wattage rating of the regen resistor if the actual application regen dissipation is unknown).

% of rated continuous output current	Power Dissipation (Watts)							
	T200-300 [W]	T200-310 [W]	T200-400 [W]	T200-410 [W]	T200-500 [W]	T200-510 [W]	T200-610 [W]	T200-710 [W]
0	35	48	35	48	35	50	50	50
25	50	63	65	80	100	110	130	175
50	65	78	100	110	165	180	220	300
75	80	93	130	140	225	240	300	430
100	97	110	160	175	290	300	400	550

Table 3.3:- Estimated Power Dissipation for the T200 Servo-drives

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3.4 T200 Connector Terminals

Figures 3.4 and 3.5 below detail the connectors on the T200-X10 (unit with internal high power PSU) and the T200-X00 (unit without internal high power PSU) respectively.

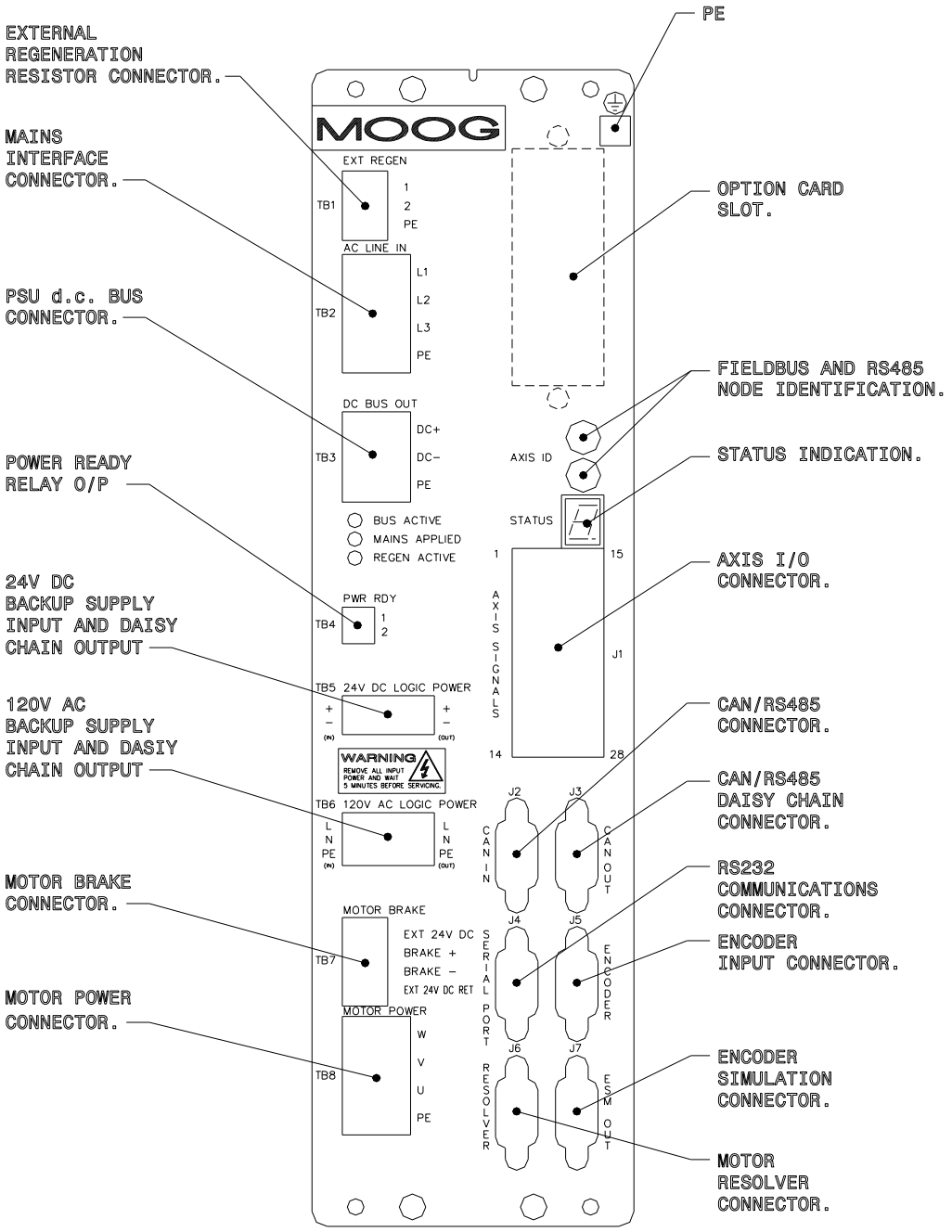

Figure 3.8:- T200-3/4/5 Front Panel (T200-X10 with Integral PSU)

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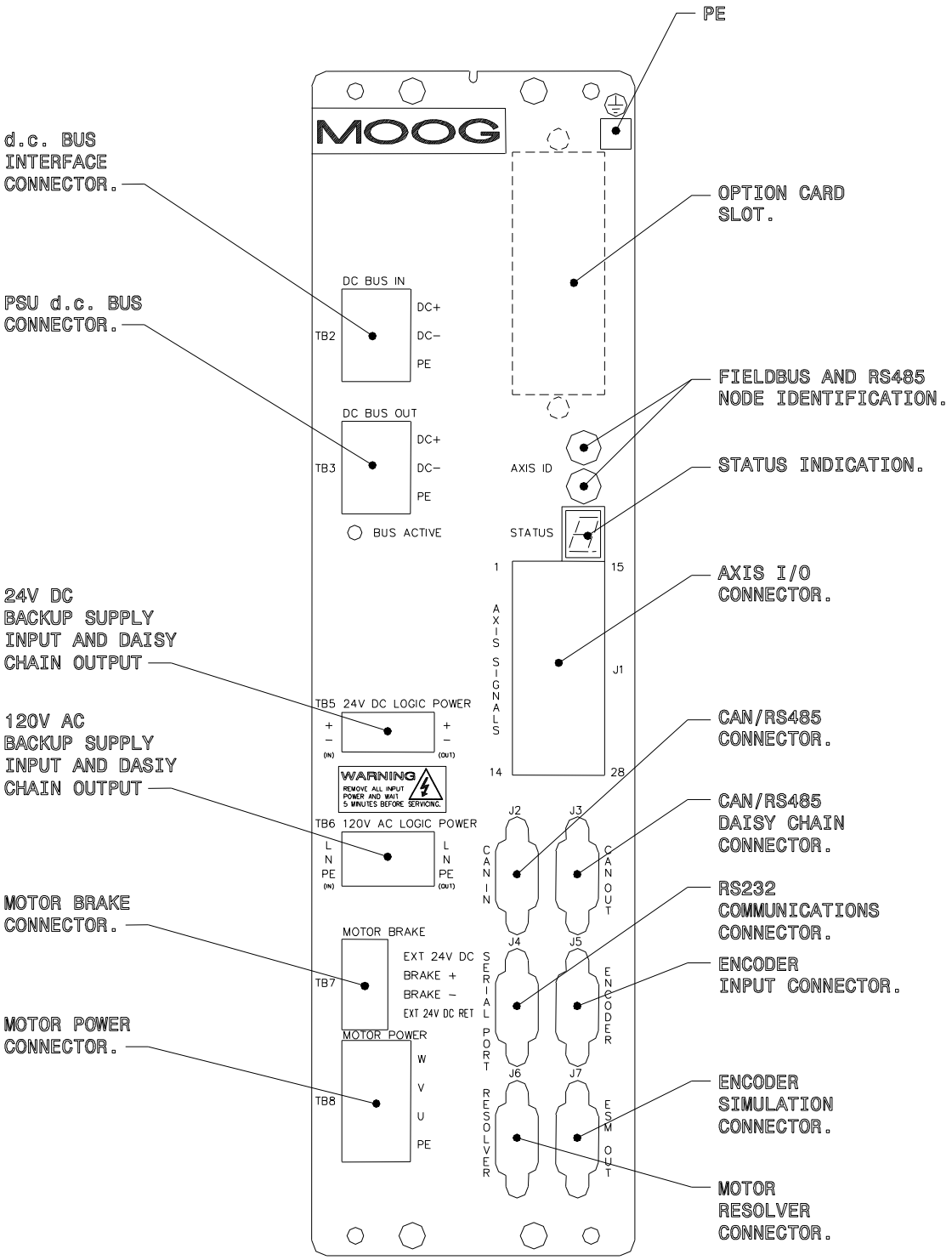

Figure 3.9:- T200-3/4/5 Front Panel (T200-X00 without Integral PSU)

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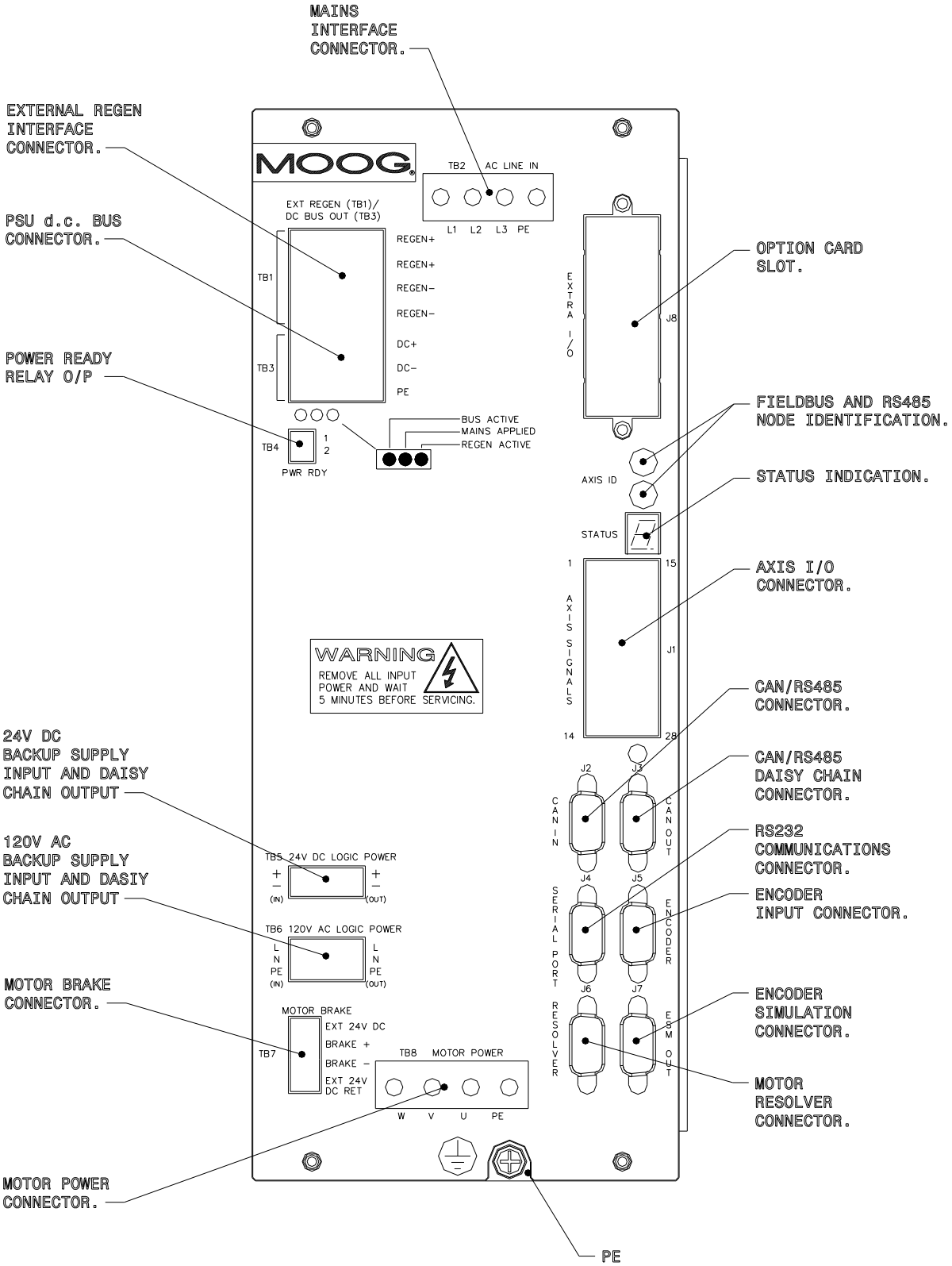

Figure 3.10:- T200-610 and T200-710 Front Panel

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3.5 General System Wiring Guidelines

The following is a general reminder of the cable requirements for the T200 Series Servo-drives and related equipment.

NOTE - Cabling and component wiring is critical in obtaining successful operation of the system. Pay close attention to specified wiring practice, cabling information, earthing and shielding requirements. Improper wiring can result in electrical noise generation and unstable motor performance.

Size wire in accordance with standard wiring practice and local codes for amperage and wire length requirements.

Avoid close parallel routing of signal wires and power wires, both inside and outside of the control cabinet. High voltage bus wires should be twisted and their length should be minimised.

Ensure proper chassis earths on all equipment. Terminate all individual chassis earths from power supply and servo-drives to a single tie point, (i.e. cabinet earth bus). Keep the distance from earth bus to earth ground as short as possible. Similarly, keep distance from servo-drive and power supply chassis earths to the tie point as short as possible. Chassis earth should be run close to D.C. Bus wires to minimise EMI. The impedance between the earth terminal and any accessible part of the equipment enclosure or cabinet should be less than or equal to 0.1 Ω

Tighten all terminal screws securely to avoid faulty operation. Torque screws to the specified values noted on the installation drawings.

All connections to the T200-3, 4 and 5 Series Servo-drives are through removable plug-in mating connectors. Do not solder the ends of the cables to be inserted into screw clamp terminals. All connections to the T200-6 and T200-7 models are the same as those to the T200-4/5/6 models, with the exception that the motor power, ac mains, DC Bus and regeneration connections to the T200-6 and 7 are via screw terminal connections.

WARNING – The removable plug-in mating connectors are for ease of wiring and are not suitable for connection or dis-connection when power is applied. All dis-connections must be made with power removed.

WARNING - All electrical supply wires and cables to this equipment must be installed in conduits (cable routings) which are smooth and free from sharp edges.

CAUTION - Shielded cable is required to be installed by the user for many external user cable connections to the T200 Servo-drive. Details of areas where shielded cable must be installed and details of earthing arrangements which must be implemented for the shields of such cables are given in the relevant sections.

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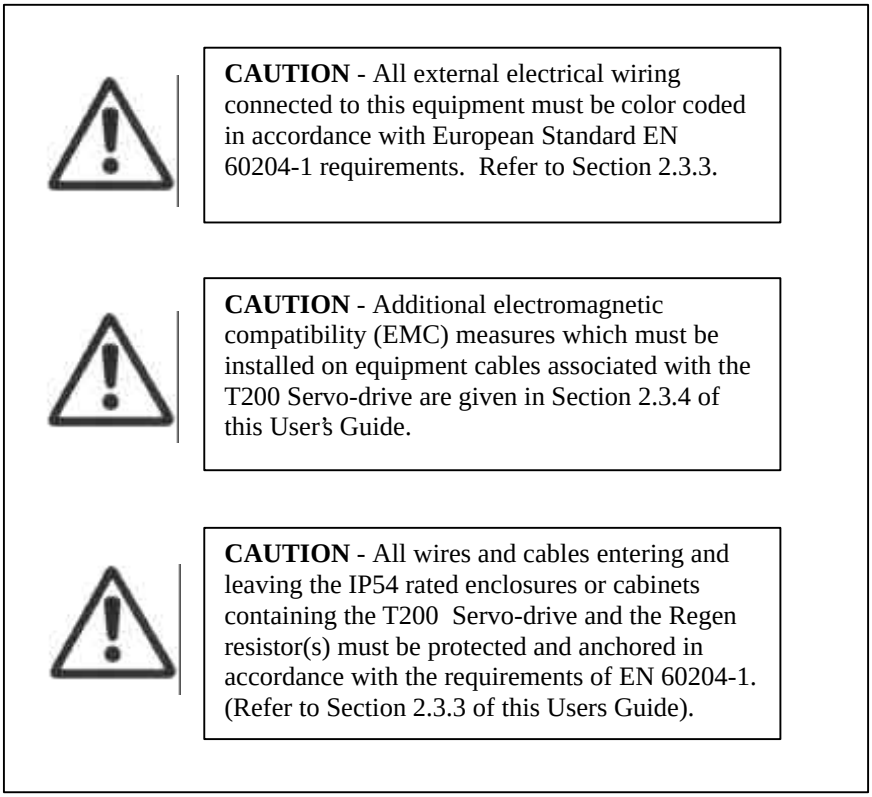
CAUTION - All external electrical wiring connected to this equipment must be color coded in accordance with European Standard EN 60204-1 requirements. Refer to Section 2.3.3.
CAUTION - Additional electromagnetic compatibility (EMC) measures which must be installed on equipment cables associated with the T200 Servo-drive are given in Section 2.3.4 of this User's Guide.
CAUTION - All wires and cables entering and leaving the IP54 rated enclosures or cabinets containing the T200 Servo-drive and the Regen resistor(s) must be protected and anchored in accordance with the requirements of EN 60204-1. (Refer to Section 2.3.3 of this Users Guide).

3.5.1 Power Circuit Breaker (User Supplied)

An a.c.-mains Circuit Breaker should be installed in series with the incoming a.c. primary power input lines. The circuit breaker should be sized so that it provides adequate (RMS) r.m.s protection based upon power supply kW rating. See Table 3.1: T200 Input Power Ratings versus Single and Three Phase Mains Voltage Level, for a list of the input power ratings of the T200 at various common voltage levels. Surge current tolerance and single-phase protection should also be considered when selecting a circuit breaker (supply disconnecting device).

3.5.2 Drive Contactor (User Supplied)

A contactor (suitably rated for the particular T200. See Table 3.1: T200 Input Power Ratings versus Single and Three Phase Mains Voltage Level) should be installed just before the Mains Input Connector TB2 of the T200-X10 units. The contactor acts as a remote switch which may cut off the mains supply in the event of an emergency shutdown. This contactor should be sized based on the continuous power of the system. A rule of thumb of 5 amps/kW continuous power can be used.

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3.6 Sequence of Component Wiring Recommendations

The following sequence for wiring is a recommendation. Individual wiring steps are denoted by a box character, which can be used as an installation check off list.

The terminal block layout on all power supplies and servo-drives has been designed to isolate low voltage from high voltage circuits. Cabinet conduits should be arranged to maintain this physical separation.

a) Power Circuit Wiring

- Wire a.c. mains input to a user supplied Circuit Breaker. Make a secure and reliable connection between the chassis of the equipment and Earth.
- **ONLY IF CE Compliance is required AND Single-Phase Mains is used**:- Fit a suitable EMC Mains Line Filter, e.g. Schaffner FN350-12-29, between the circuit breaker and the contactor. The current rating of the EMC Mains Line Filter is application dependant. For details of the EMC test conditions, see Appendix A.
- If a step down Mains Transformer is used, wire mains from the Circuit Breaker to the primary of the Transformer.
- If a step down Mains Transformer is used, wire 230 V a.c. three phase from the transformer secondary or plant 230 V a.c. source to a user-supplied contactor. Otherwise wire the a.c. mains from the circuit breaker or the EMC filter to the user-supplied contactor.
- Wire a.c. mains from the user-supplied contactor to the power input poles at TB2 of the T200.

For T200 Servo-drives that do not have an Internal Power Supply:

- Connect the D.C. Bus Input to either:
  1. the D.C. Bus output of a T200 Servo-drive with an Internal Power Supply (See Figure 3.14); or
  2. to the daisy-chained D.C. Bus output of a T200 Servo-drive without an Internal Power Supply (See Figure 3.14).

b) Servo-drive Wiring

- Plug in Axis I/O cable to J1 and connect other end to user I/O equipment. In particular, connect the Power Ready signalling between a T200-X10 and any T200-X00 units which draw power from its D.C. Bus.
- Plug in resolver cable at J6.
- Plug in 24 Vd.c. or 120 Va.c. Control-Backup Power cable to TB4 or TB5 respectively. Connect the other end of the cable to the user supplied 24 V d.c. or 120 V a.c. power supply.
- Connect appropriate communications cabling (RS232 at J4, RS485 at J2 and J3, or CAN at J2 and J3)

c) Motor Wiring

- Repeat the steps listed in this Section for each motor in the system.
- Plug in and screw tight resolver/signal cable to motor resolver connector.
- Plug in and screw tight motor power cable to motor power connector. Also connect the brake terminations at TB7.

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3.7 Three-Phase A.C. Mains Power Source Configuration

The T200 may be supplied from a three-phase a.c. mains input. In this case the following user supplied options are required:-

1. Three-Phase Mains Circuit Breaker
2. Mains Matching Transformer (400/440/480Va.c. to 230Va.c.)
3. Mains Contactor

For a control-backup power source either of the following may be used:-

1. 24Vd.c. Power Source OR
2. 120Va.c. Power Source. This power source must provide galvanic isolation between the 120Va.c. output (to be connected to the T200 at TB6) and the T200's a.c. mains inputs.

Note that if the a.c. mains is still applied, and the control-backup power is removed, then the T200 control section will still operate correctly. Control power can still be generated from the high voltage D.C. Bus.

Figure 3.11 below outlines typical interconnect in a multi-axis T200 system, which is powered by 3-phase a.c. mains supply.

NOTE - If the T200 is used in three-phase mode, then an isolation transformer must be used

CAUTION If the 120Va.c. logic backup power supply option is used, the 120Va.c. output for connection to the T200, MUST be galvanically isolated from the T200's a.c. mains input, otherwise damage to the T200 may occur.

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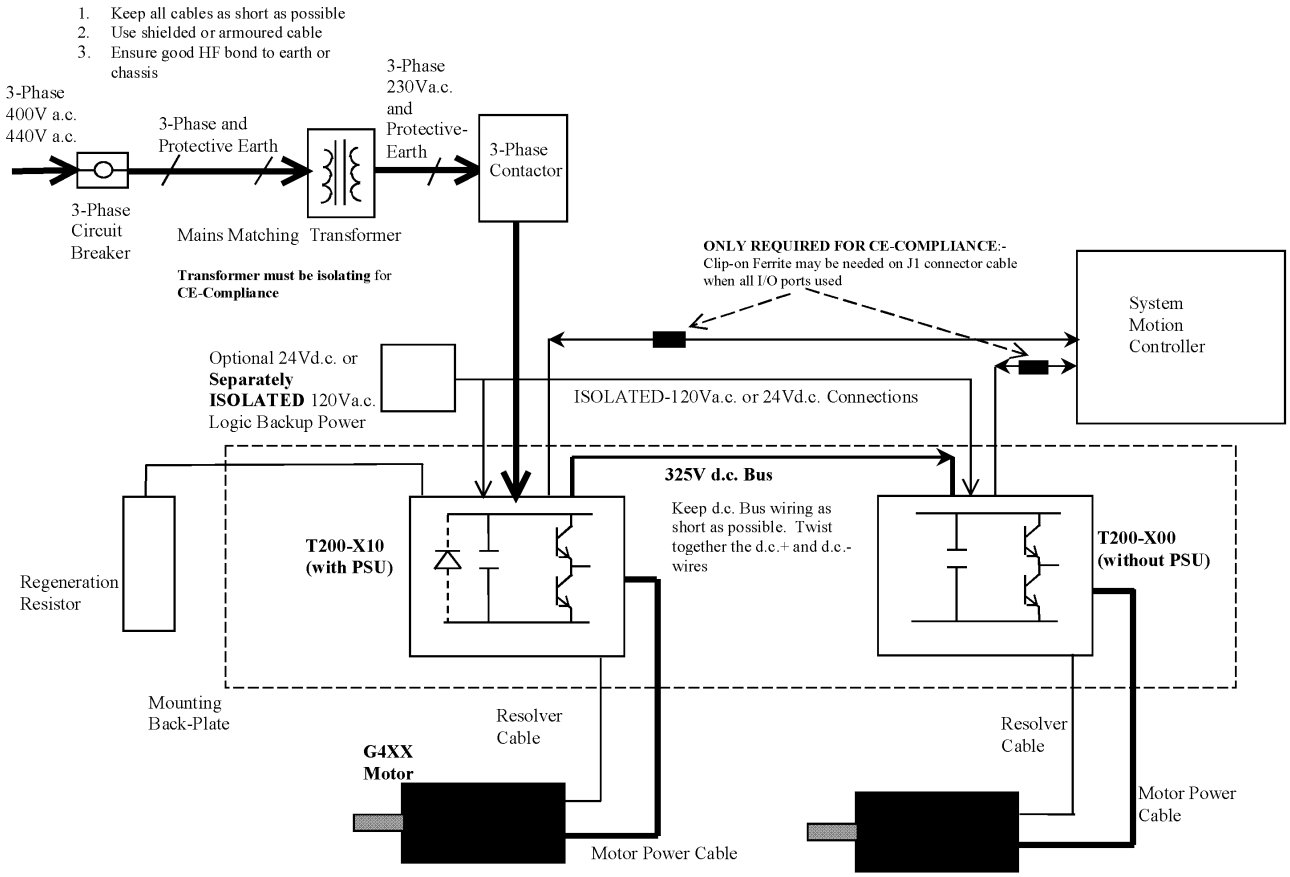
1. Keep all cables as short as possible
2. Use shielded or armoured cable
3. Ensure good HF bond to earth or chassis
3-Phase 400V a.c. 440V a.c.
3-Phase and Protective Earth
3-Phase 230Va.c. and Protective-Earth
3-Phase Contactor
3-Phase Circuit Breaker
Mains Matching Transformer
Transformer must be isolating for CE-Compliance
ONLY REQUIRED FOR CE-COMPLIANCE:- Clip-on Ferrite may be needed on J1 connector cable when all I/O ports used
System Motion Controller
Optional 24Vd.c. or Separately ISOLATED 120Va.c. Logic Backup Power
ISOLATED-120Va.c. or 24Vd.c. Connections
325V d.c. Bus
Keep d.c. Bus wiring as short as possible. Twist together the d.c.+ and d.c.- wires
T200-X10 (with PSU)
T200-X00 (without PSU)
Regeneration Resistor
Mounting Back-Plate
Resolver Cable
Resolver Cable
G4XX Motor
Motor Power Cable
Motor Power Cable

Figure 3.11:- T200 Multi-Axis system with 3-Phase A.C. Mains Inputs

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3.8 Single Phase 230Va.c. Mains Configuration

The T200-310/410/510 Models only may be driven by single-phase 230Va.c.-mains input. In this case the following user supplied options are required:-

1. Single-Phase Mains Circuit Breaker
2. Mains Contactor

For a control-backup power source, any of the following may be used:-

1. 24Vd.c. Power Source or
2. 120Va.c. Power Source. This power source must provide galvanic isolation between the 120Va.c. output (to be connected to the T200) and the T200's a.c. mains inputs.

Note again, that if the a.c. mains is still applied, and the control-backup power is removed, then the T200 control section will still operate correctly. Control power can still be generated from the high voltage D.C. Bus.

Figure 3.7 below outlines typical interconnect in a multi-axis T200 system, which is powered by single-phase 230V a.c. mains.

NOTE - If the T200 is used in single-phase mode, an EMC a.c. mains line filter is required to achieve conducted-emissions compliance.

CAUTION:- If the 120Va.c. logic backup power supply option is used, the 120Va.c. output for connection to the T200, MUST be galvanically isolated from the T200's a.c. mains input, otherwise damage to the T200 may occur.

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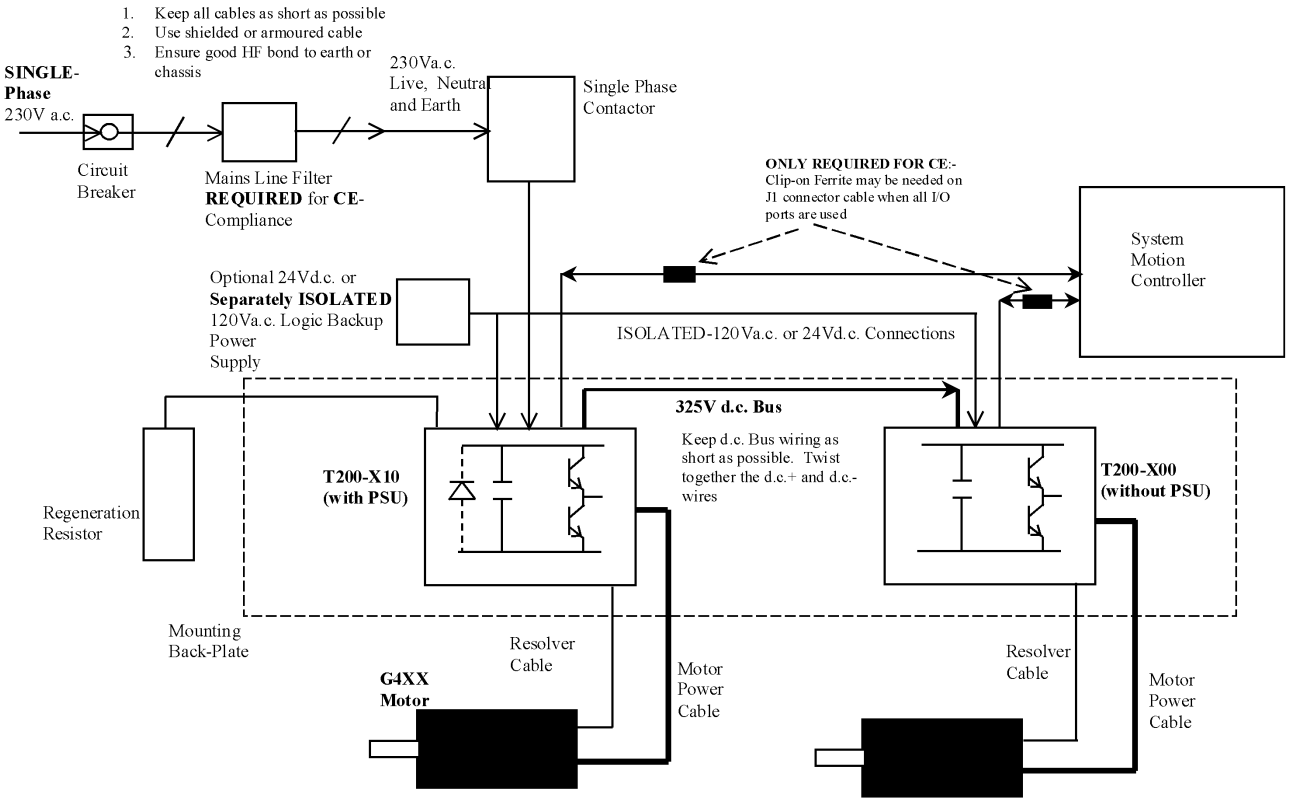
1. Keep all cables as short as possible
2. Use shielded or armoured cable
3. Ensure good HF bond to earth or chassis
SINGLE-Phase 230V a.c.
Circuit Breaker
Mains Line Filter REQUIRED for CE-Compliance
230Va.c. Live, Neutral and Earth
Single Phase Contactor
ONLY REQUIRED FOR CE:- Clip-on Ferrite may be needed on J1 connector cable when all I/O ports are used
System Motion Controller
Optional 24Vd.c. or Separately ISOLATED 120Va.c. Logic Backup Power Supply
ISOLATED-120Va.c. or 24Vd.c. Connections
325V d.c. Bus
Keep d.c. Bus wiring as short as possible. Twist together the d.c.+ and d.c.- wires
T200-X10 (with PSU)
T200-X00 (without PSU)
Regeneration Resistor
Mounting Back-Plate
Resolver Cable
Motor Power Cable
G4XX Motor
Resolver Cable
Motor Power Cable

Figure 3.12:- T200 Multi-Axis system with Single-Phase 230Va.c. Mains Input (T200-310/410/510 Models only)

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3.9 Single Phase 120Va.c. Mains Configuration

The T200-310/410/510 Models only may be driven by single-phase 120V a.c. mains input. In this case the following user supplied options are required:-

1. Single-Phase Mains Circuit Breaker
2. Mains Contactor

For a control-backup power source, one of the following MUST be used:-

1. 24Vd.c. Power Source or
2. 120Va.c. Power Source

CAUTION:- In this case the user must supply either a 24Vd.c. or a 120Va.c. control-backup power supply. The D.C. Bus is at too low a voltage level to allow control power to be derived from it when 120Va.c. mains is used for the high power input on TB2. If the 120Va.c. option is used, then the 120Va.c. supply MUST be isolated from the 120Va.c. source used for the mains input supply.

Figure 3.13 below outlines typical interconnect in a multi-axis T200 system, which is powered by single-phase 120V a.c. mains.

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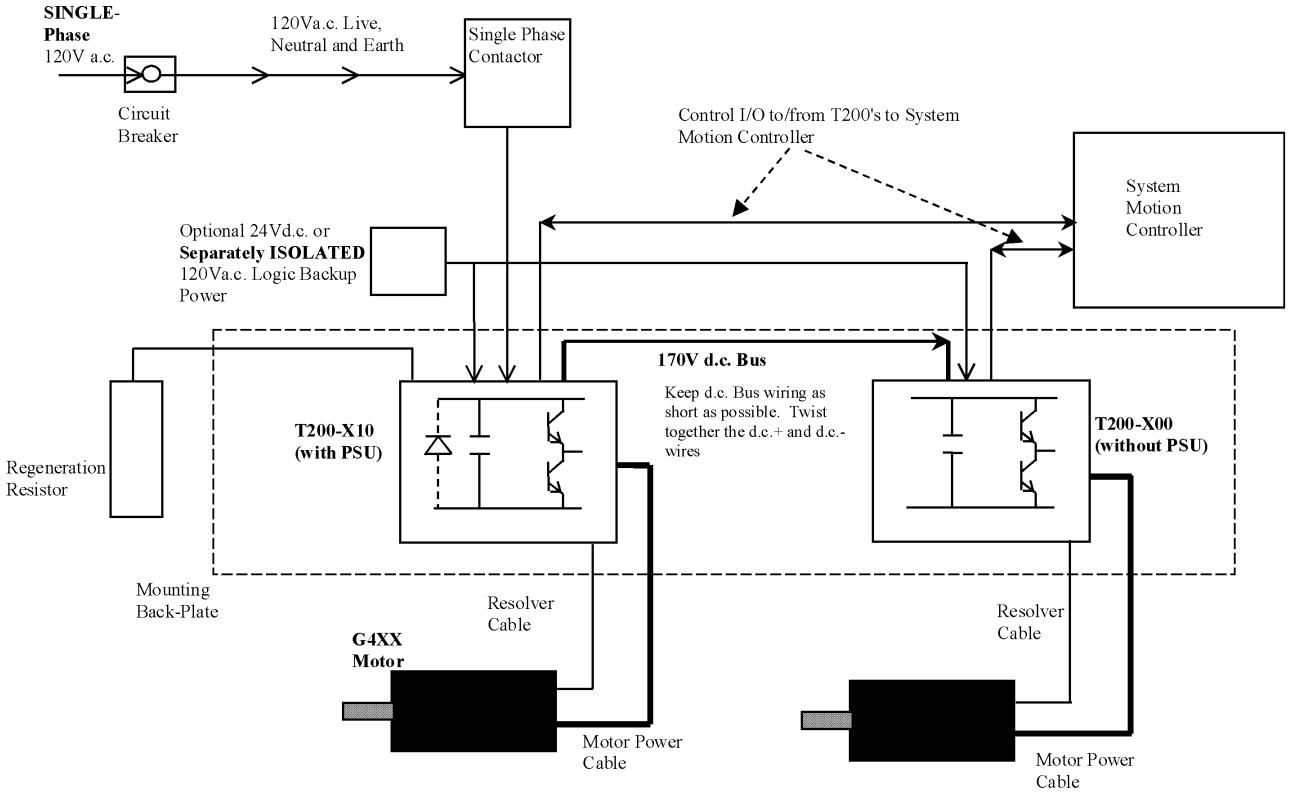

Figure 3.13:- T200 Multi-Axis system with Single-Phase 120V A.C. Mains Inputs (T200-310/410/510 Models only)

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3.10 Providing D.C. Bus Power from a T200-X10 Unit to T200-X00 Units

A T200-X10 unit contains an a.c. mains rectification stage, which generates a D.C. Bus voltage from the a.c. mains. A T200-X00 unit does not contain this rectification stage. It accepts a high power input only in the form of a high voltage D.C. Bus. This D.C. Bus is fed from a T200-X10 unit to one or several T200-X00 units, which are connected to the T200-X10 in a daisy-chain configuration.

WARNING:- For 230Va.c. mains input, the magnitude of the D.C. Bus voltage is approx. 325Vd.c. The D.C. Bus terminals at TB3 of the T200-X10, and at TB2 and TB3 of the T200-X00, have lethal voltages present. All T200 terminals should not be accessed for service or other purposes before removal of all power and waiting 5 minutes for all internal voltages to decay to harmless levels.

Figure 3.14 shows the interconnect of the D.C. Bus from a T200-X10 to T200-X00 units which share high power via the D.C Bus.

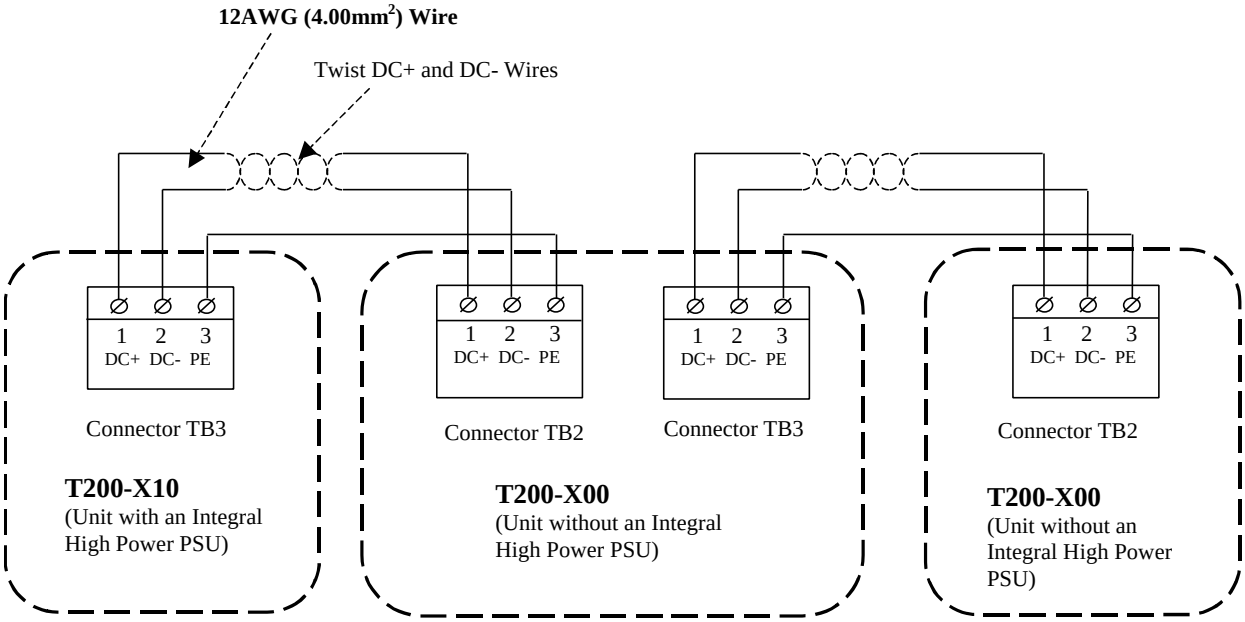

Figure 3.14:- Daisychaining the High Voltage D.C. Bus from a T200-X10 to T200-X00 Units

CAUTION:- The T200-X10 D.C. Bus output (on connector TB3) will conduct up to 20Ar.m.s. continuously. If the T200-X10 or T200-X00 D.C. Bus connections (D.C.+ and D.C.-) from a T200-X10 to a T200-X00 are reversed in polarity, then the T200 will be damaged because of a high current which flows out of the T200-X10 DC+ terminal on TB3. A T200-X10 which is damaged in this way must be returned to Moog for repair, and should not be opened for service by the user.

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There is a limitation to the number of T200-X00 units that can be attached to a T200-X10. This limitation is summarised below.

CAUTION:- **Limit on Number of Units without PSU Connected to a T200 Unit with PSU (T200-X10)**

The D.C. Bus output of a T200-X10 is capable of supplying up to 6.5kW continuously when connected to three phase mains. The user should calculate the continuous electrical power requirements for each axis in the application. The following conditions apply:-

- The sum of the electrical power requirements, including all T200's (i.e. one T200-X10 and several T200-X00's) connected in a daisy-chain via the D.C. Bus, should not exceed the rated continuous input power limit summarised for each T200-X10 model in the table below.

T200 Model	T200-310	T200-410	T200-510	T200-610	T200-710
Rated Continuous Input Power	7.5kW	7.5kW	7.5kW	15.0kW	15.0kW

- The sum of the electrical power requirements of all T200-X00's (i.e. all of the units which do not contain an integral A.C. Mains PSU), connected in a daisy-chain via the D.C. Bus, should not exceed **6.5kW**.

- The absolute maximum number of connected T200-X00 units is hard limited to 4, irrespective of the calculations above.

If in doubt, consult Moog applications engineering for advice on sizing how many units without mains interface PSU (T200-300 to T200-500) units can be connected to a unit with mains interface PSU (T200-310 to T200-710).

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3.10.1 Power Ready Signalling from T200-X10 to Connected T200-X00 Units

The T200-X10 units contain a soft-start function. The soft-start function limits the inrush current into the T200's D.C. Bus smoothing capacitors after the a.c. mains has been switched on. The T200 should not allow currents to flow in the motor before the softstart has completed. Otherwise the D.C. Bus capacitors are drained by motor current during the soft-start, and may never become fully charged.

3.10.1.1 The Power Ready Interconnect scheme

T200-X10 units will not allow high power to be applied to the motor phases before the soft-start has finished. This can be accomplished because the T200-X10 control units are informed via internal signalling that the soft-start process is still ongoing. However T200-X00 units, whose DC-Bus power is taken from a T200-X10, do not know, without some control input, whether the T200-X10 soft-start process is ongoing. The T200-X10 provides the Power-Ready relay output to signal to all connected T200-X00 units the status of its soft-start process.

CAUTION:- The T200-X10 can malfunction unless the Power Ready power sequencing control scheme is used. This control scheme is described in this section of the T200 User Manual. Users should ensure that this scheme is implemented if they intend to connect ANY T200-X00 units to a T200-X10.

Note that the T200 allows two options for digital input connections:-

1. The Pull-Up option is outlined in Figure 3.17
2. The Pull-Down option is outlined in Figure 3.18

The pull-up or pull-down interconnect scheme used for the Power Ready power sequencing scheme should follow the overall digital input scheme which is selected by the user.

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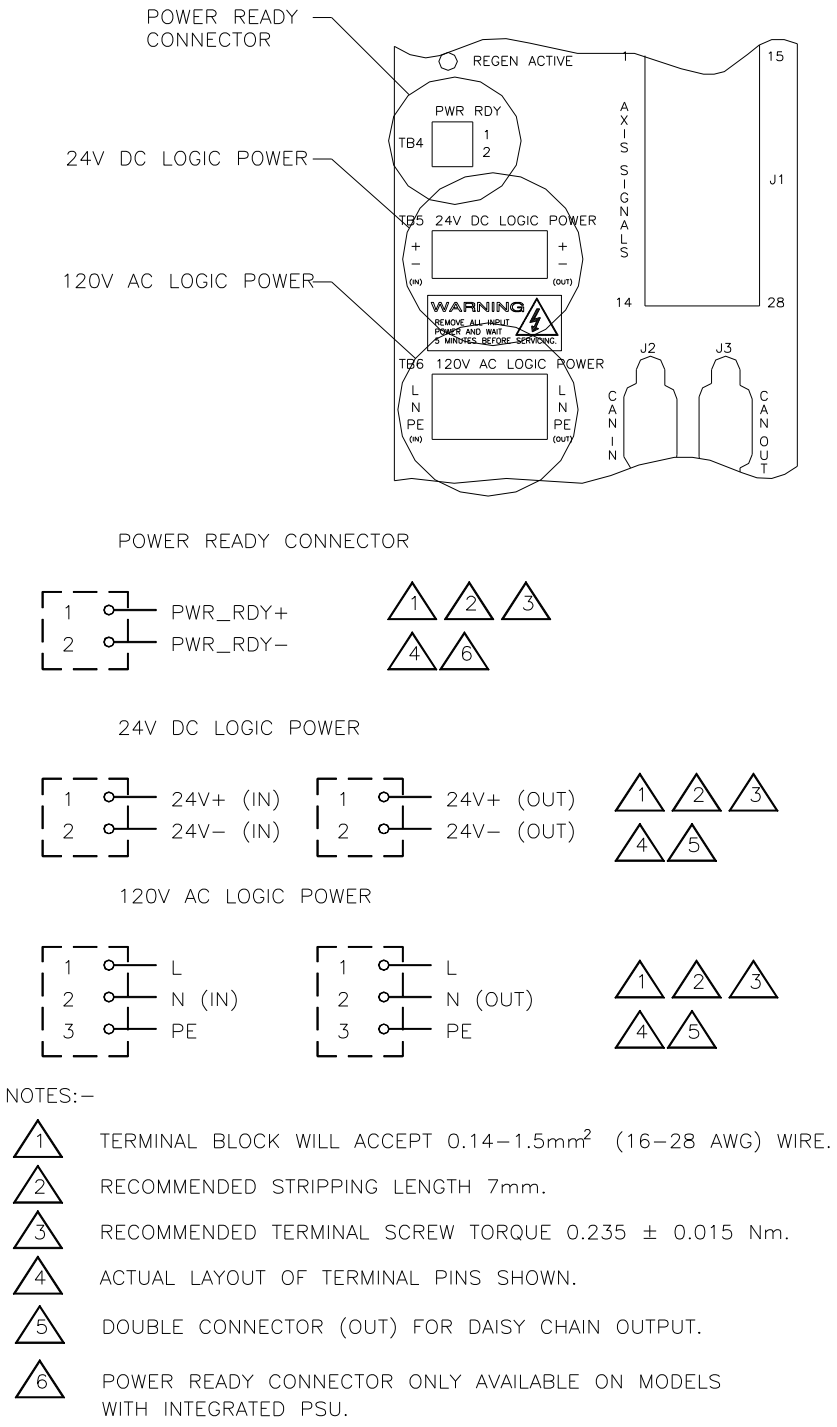

Figure 3.15:- T200 Power Ready, 24V d.c. and 120V a.c. Backup Connections

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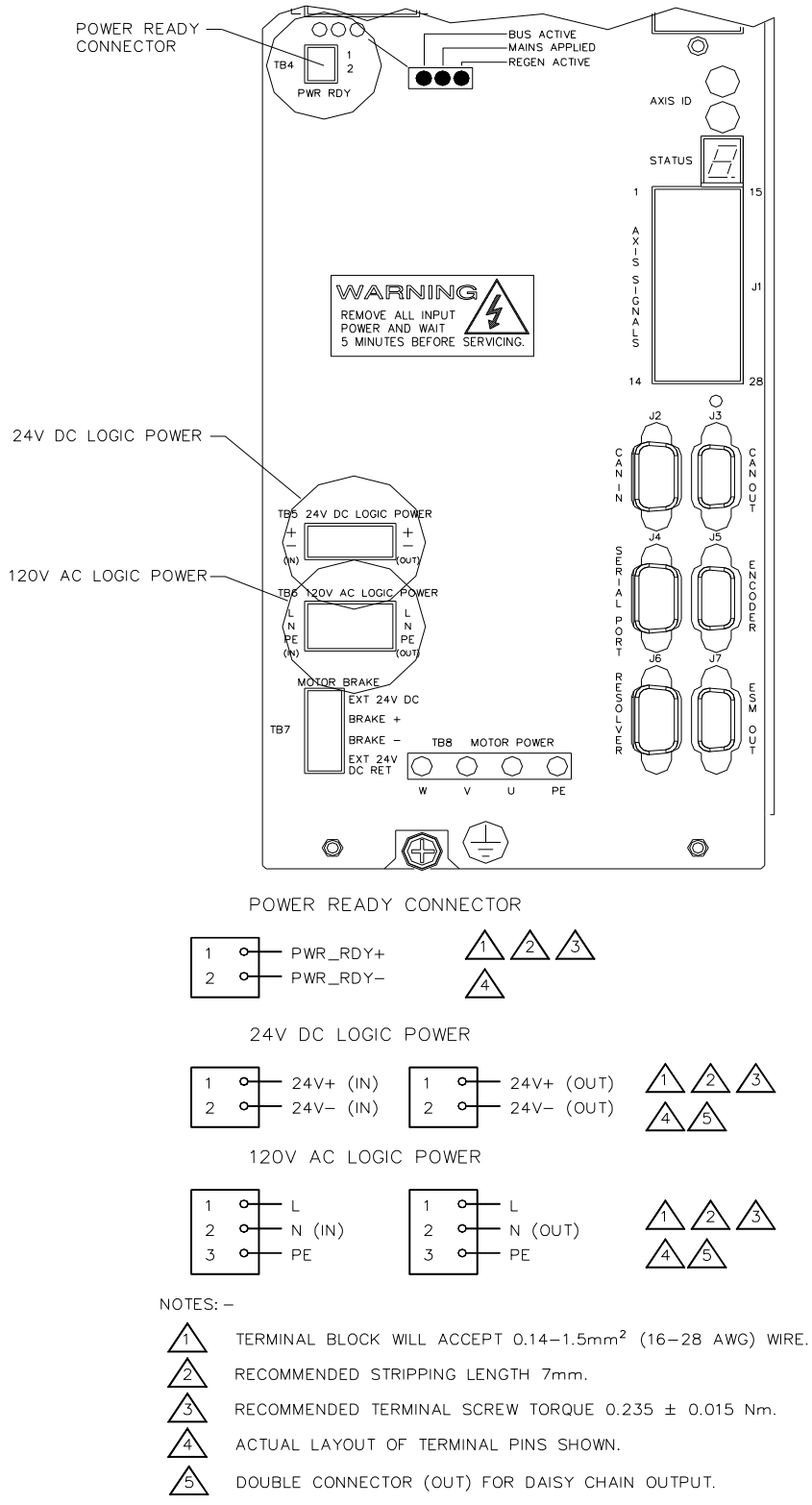

Figure 3.16:- T200-610/710 Power Ready, 24V d.c. and 120V a.c. Backup Connections

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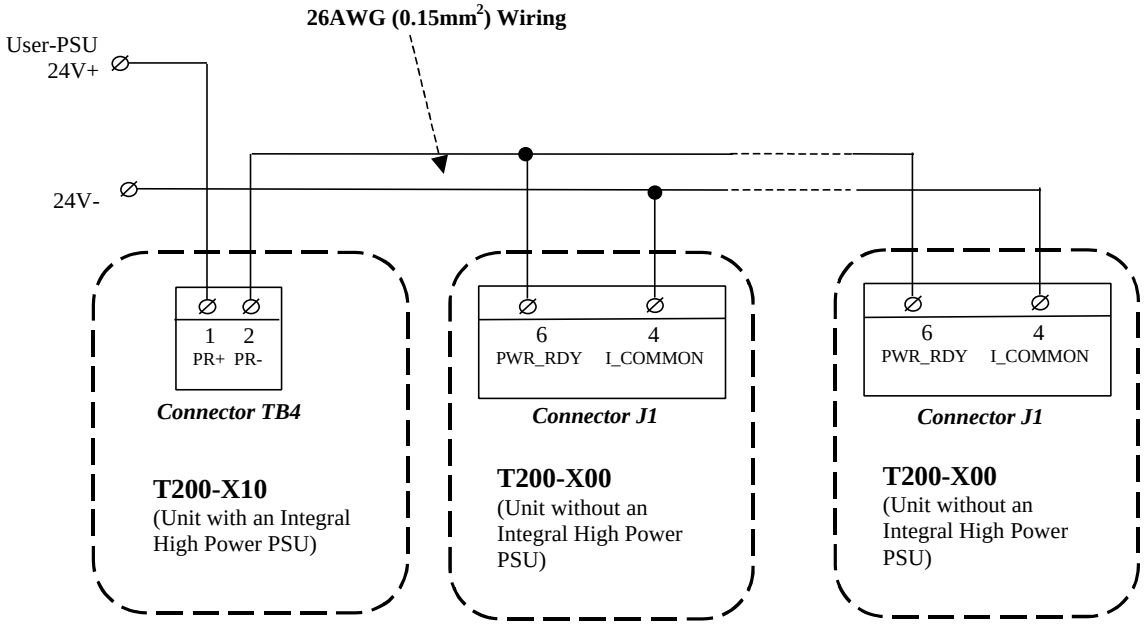

Figure 3.17:- Pull-up Power Ready Interconnect between T200-X10 and Connected T200-X00 Units (I_COMMON connected to 24V RETURN)

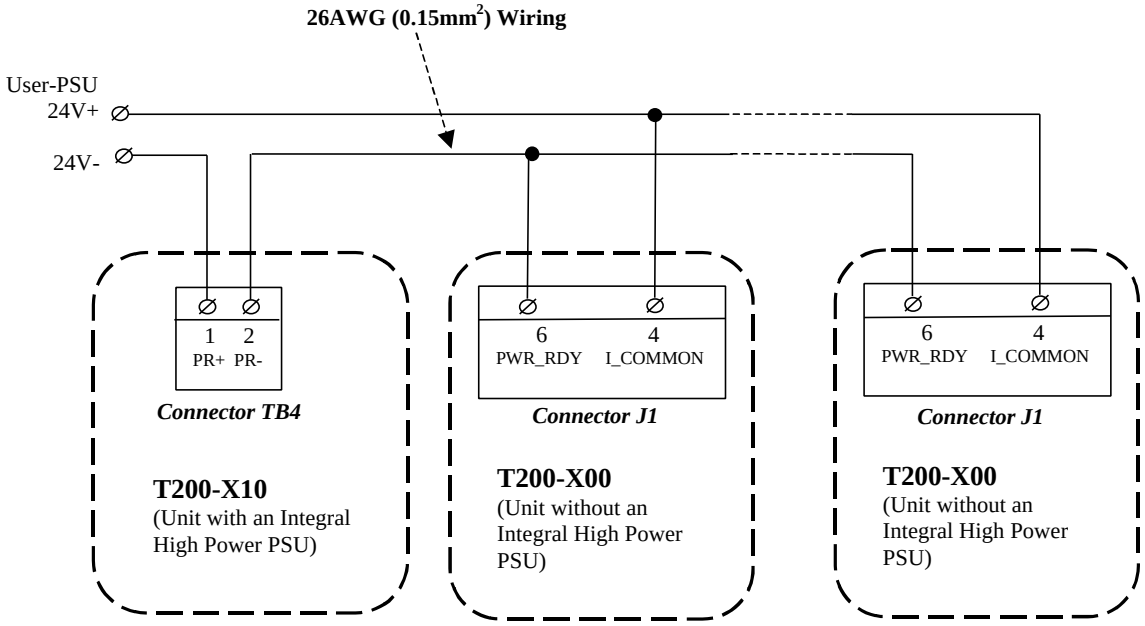

Figure 3.18:- Pull-down Power Ready Interconnect between T200-X10 and Connected T200-X00 Units (I_COMMON connected to 24V+)

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3.10.2 Power Cycling Frequency Limits

As outlined in a previous section, the T200-X10 units contain a soft-start function. The soft-start function limits the inrush current into the T200's D.C. Bus smoothing capacitors after the a.c. mains has been switched on.

If the frequency of power cycling becomes too high, then the power dissipation in the soft-start resistor can be excessive. In this case the softstart circuitry may become damaged.

CAUTION:- The following rule should be borne in mind when power cycling the a.c. mains:-

Within any two minute period, the a.c. mains supply should not be cycled on and off more than 6 times.

If this rate is exceeded then the internal softstart circuitry may be damaged, and the F3 fault will be displayed on the 7-segment display. In this case the T200 must be returned to the Moog for repair.

There is also a restriction on the minimum time between a.c. mains power cycling. If this rate is exceeded then the internal regeneration circuitry may be damaged and the T200 will have to be returned to Moog for repair. Note that:-

The minimum time between any two consecutive a.c. mains power cycles is 4.5 seconds.

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3.11 Paralleling T200-X10 Units through the D.C. Bus

T200-X10 units can be paralleled via the D.C. Bus, in order to share regeneration power. In Figure 3.19, below, the T200-X10 units are shown with the a.c. mains inputs connected to all T200-X10 units. The user can also connect the D.C. Bus outputs of the T200-X10's at TB3 in order to share regeneration power.

CAUTION:- If a T200-X10 unit does not see a high a.c. voltage at pins 1, 2 or 3 of terminal TB2, then the T200-X10 will continuously activate the fast bus discharge. This will cause damage to the internal regeneration circuitry, if a high d.c voltage is present at connector TB3. The T200 will then have to be returned to the factory for repair.

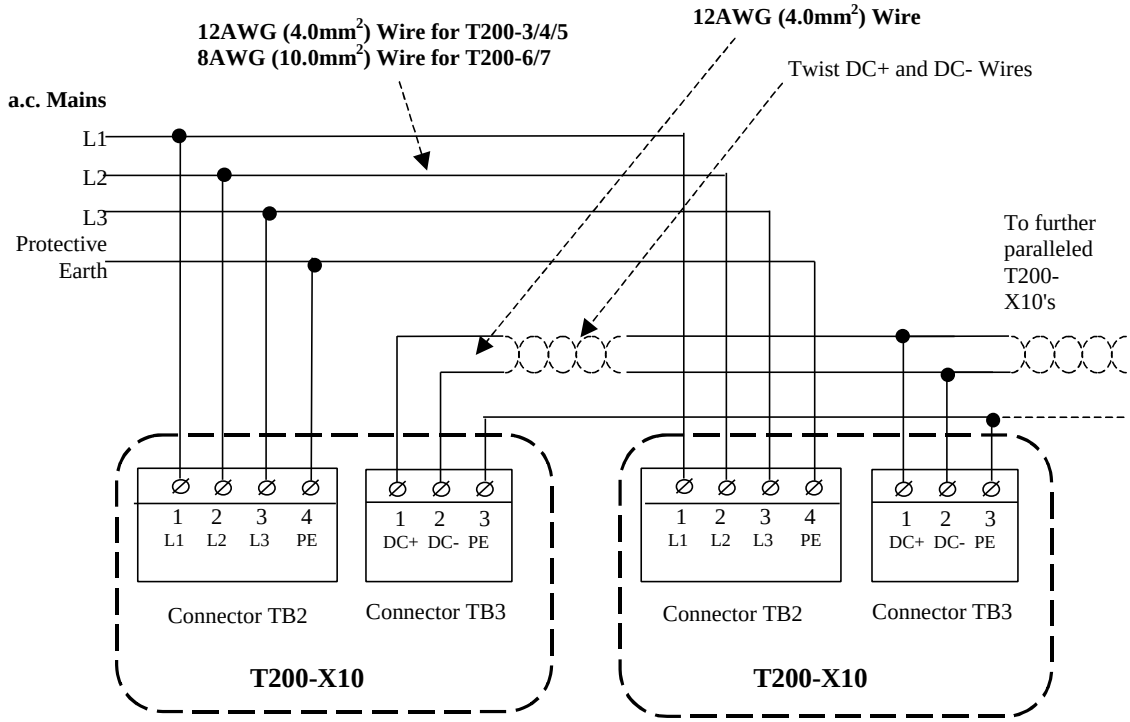

Figure 3.19: Paralleling T200-X10 Units through the D.C. Bus

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3.12 Daisychaining Control-Backup Power Connections to T200's

The T200 contains extra connector terminals which allow easy connection of the 24Vd.c. and 120Va.c. control-backup power.

3.12.1 24Vd.c. Control-Backup Power Daisychaining

Connections to wire the 24Vd.c. control backup power are shown Figure 3.20 below.

NOTE:- The T200 contains a resetable fuse on the 24Vd.c. input. If the 24V backup power is connected in reverse, then an over-current on the 24V+ and 24V- terminals will cause the fuse to go open circuit. If the faulty connection is removed, the fuse will reset after a short period.

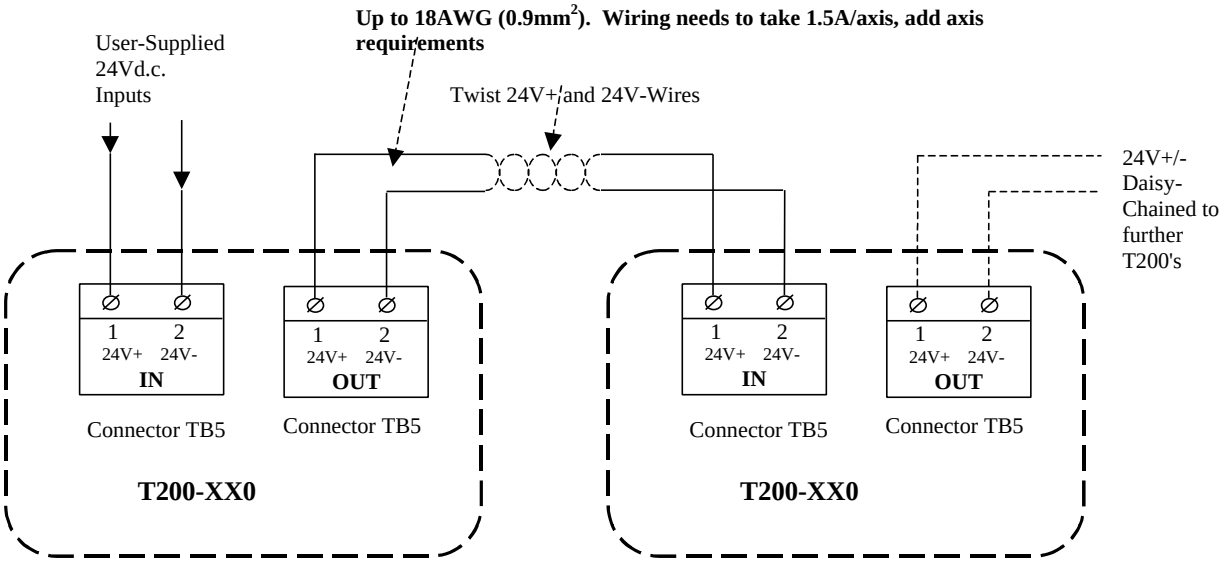

Figure 3.20: Daisychaining the 24Vd.c. backup power from one T200 to the next

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3.12.2 120Va.c. Control-Backup Power Daisychaining

Connections to wire the 120Va.c. control backup power are shown in Figure 3.21.

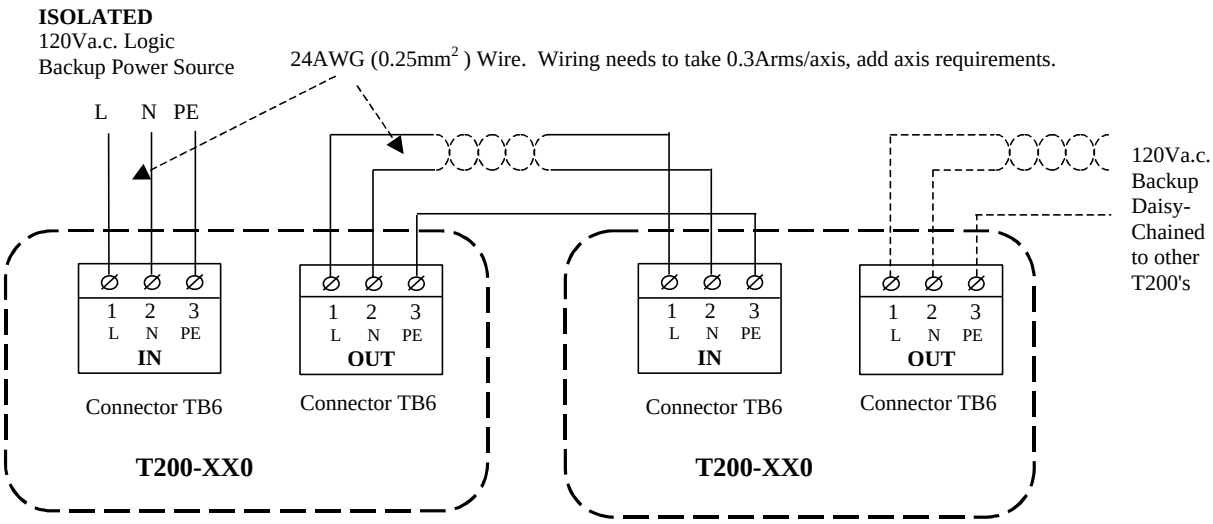

Figure 3.21: Daisy-Chaining the 120Va.c. backup Input from one T200 to the Next T200

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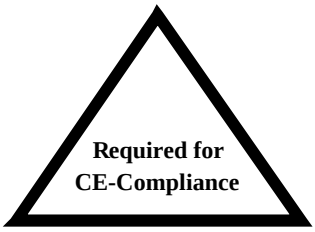
3.13 Internal/External Regeneration (Regen) Resistors – Configurations

Regeneration resistors can only be fitted to T200 servo-drives with an Internal Power Supply (i.e. Model Numbers. T200-X10). The T200-310/410/510 do have an internal regen resistor with a continuous power rating of 40W, peek power of 2.8kW. This regen resistor can be supplemented with an additional external regeneration resistor.

The T200-610/710 do not have an internal regen resistor. An external regen resistor is required in any case.

All external Regen resistors should be mounted to allow adequate heat dissipation and such that heat from the Regen resistor is not directed to air intakes of other equipment.



For EMC purposes, use shielded cable to connect the external Regen resistor to the T200. The length of this cable should be as short as possible. The shields of these cables should be connected to Chassis Earth using the optional EMC kit or the panel earth bar. Alternatively, if the cable is required to pass through an enclosure panel earthed to Chassis Earth, the shield may be earthed to the panel by use of a 360 degree metal cable gland.

Refer to Section 2.3.3 and 2.4 for further safety and EMC requirements for cable installation.

NOTE - The internal regeneration resistor is protected by an internal electronic circuit breaker, which disables regeneration when the internal resistor's rating is exceeded. For an externally fitted regeneration resistor, the T200 Servo-drive monitors the regeneration duty cycle and reports a warning to the user via the Thermal Limit output (THRMAL_LIM) and seven segment display. The warning reports that the continuous regeneration power of the external resistor has been exceeded.

WARNING - External regen resistors are connected to the T200 D.C. Bus voltage that can reach 400 V d.c. Exposed metallic mounting parts of external regen resistors must be connected to protective earth and the electrically conducting parts mechanically shielded for safety. High voltage warning stickers are also recommended.

Moog can supply users with external regeneration resistors. Contact your local Moog sales office or authorised distributor for available resistor kits.

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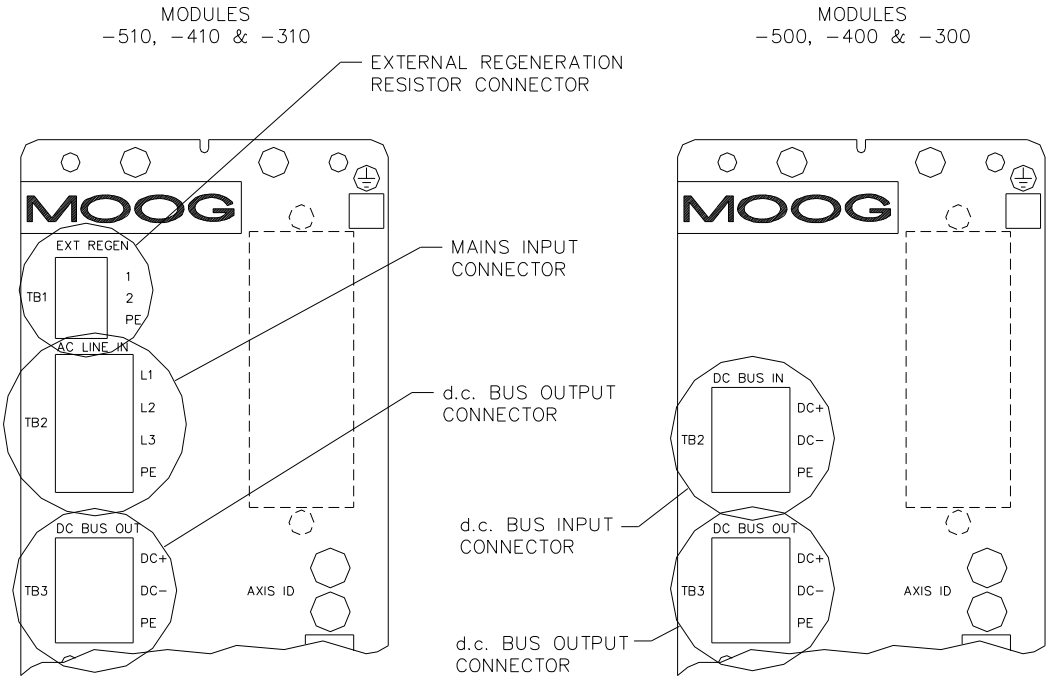

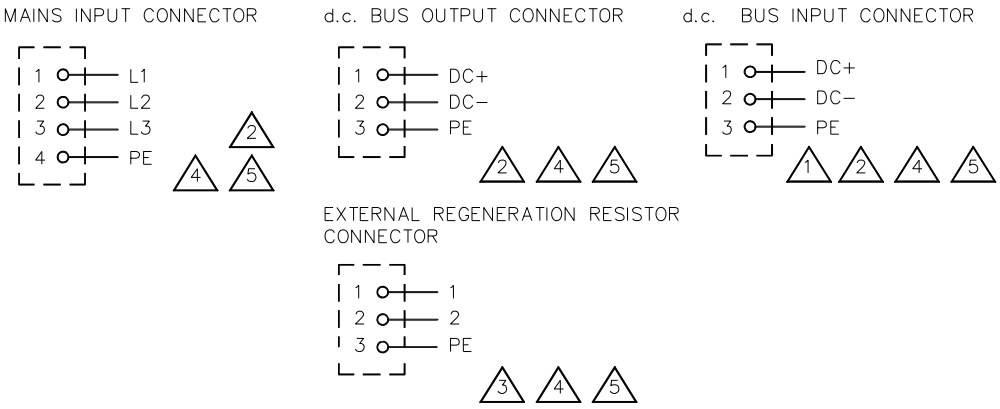

NOTES: –

1. THERE IS NO MAINS I/P CONNECTOR FOR T200 VARIANTS WITHOUT POWER SUPPLY (–300, –400 & –500). IN THESE CASES TB2 IS CONFIGURED AS A DC BUS I/P CONNECTOR.
2. TERMINAL BLOCK WILL ACCEPT 0.2–4mm^2 (10–24 AWG) WIRE.
3. TERMINAL BLOCK WILL ACCEPT 0.2–2.5mm^2 (12–24 AWG) WIRE.
4. RECOMMENDED STRIPPING LENGTH 7mm.
5. RECOMMENDED TERMINAL SCREW TORQUE 0.55 ± 0.05 Nm.

Figure 3.22: T200-310/410/510 External Regeneration and Mains Input, d.c. Bus Input and Output Connections

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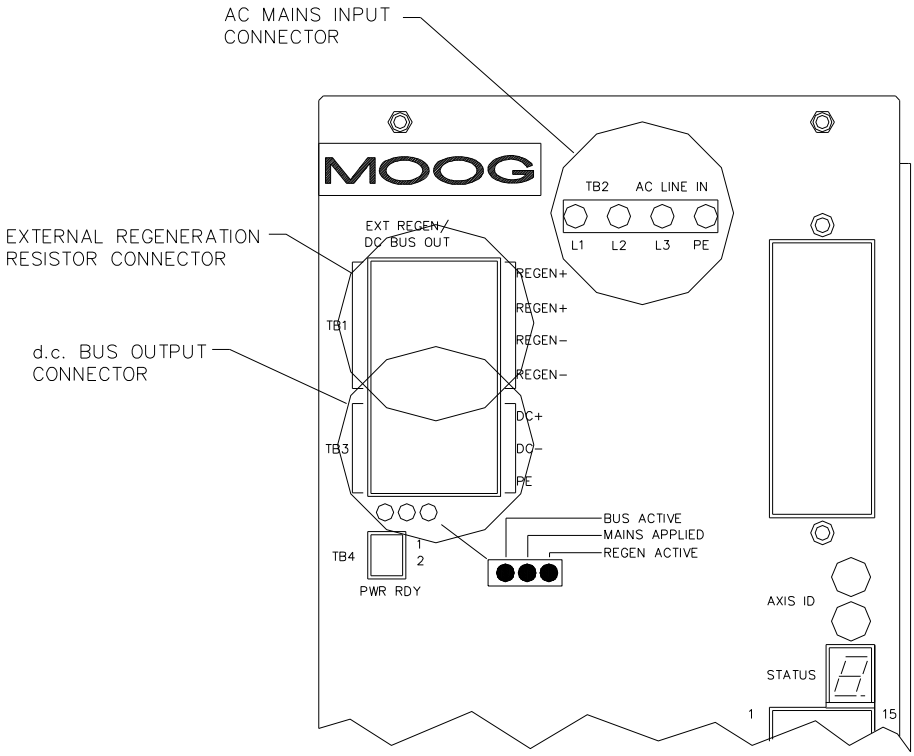

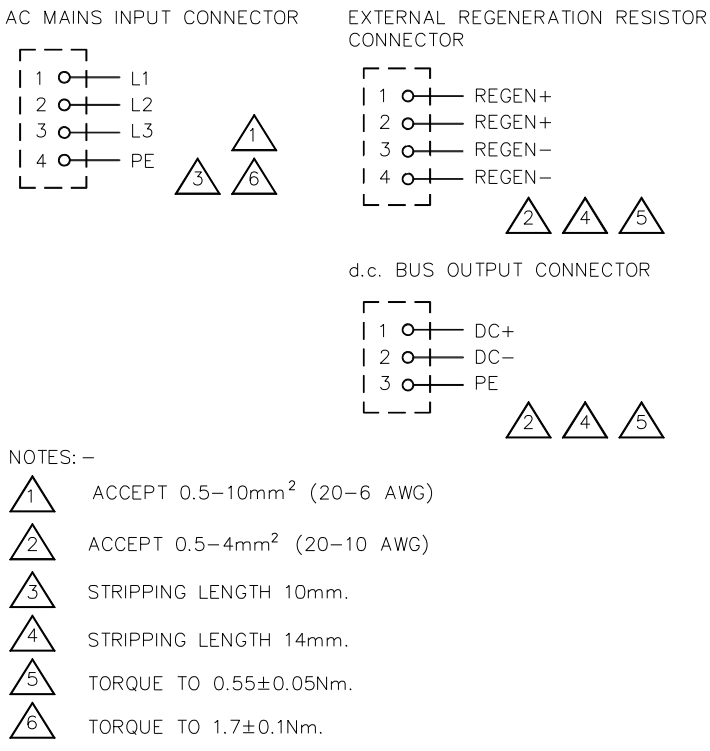

NOTES: –

1. ACCEPT 0.5–10mm² (20–6 AWG)
2. ACCEPT 0.5–4mm² (20–10 AWG)
3. STRIPPING LENGTH 10mm.
4. STRIPPING LENGTH 14mm.
5. TORQUE TO 0.55±0.05Nm.
6. TORQUE TO 1.7±0.1Nm.

Figure 3.23: T200-610/710 External Regeneration and Mains Input, d.c. Bus Input and Output Connections

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3.13.1 T200-310 External Regeneration Resistor Options

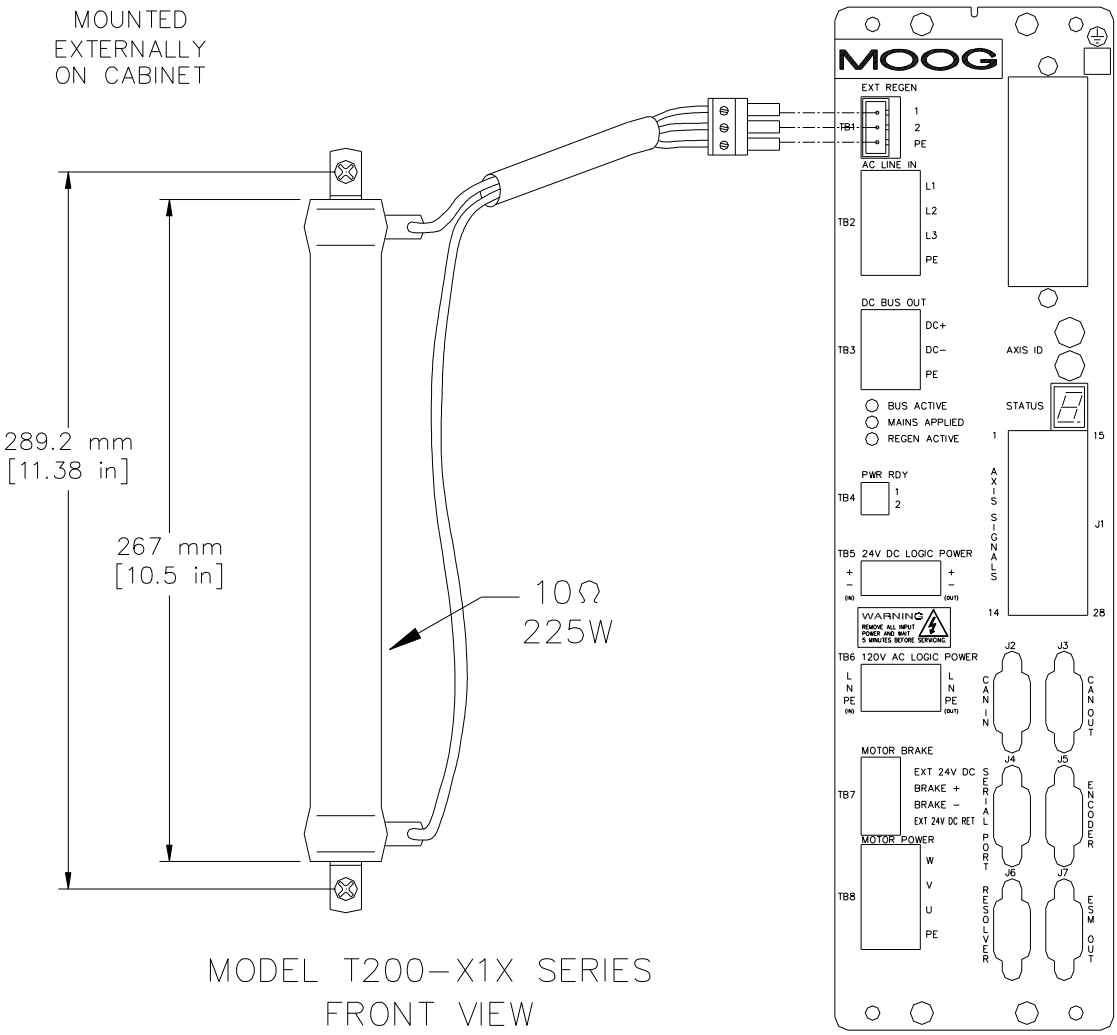

Figure 3.24:- T200-310 Regeneration Resistor 200W Option 1 – C22654-002 (Mounting and Connection)

Moog offers two regeneration resitor kit options for use with the T200-310. Figure 3.24 shows the first option for an external regeneration resistor for the T200-310 unit, which uses a 225W-rated resistor operated at a maximum continuous dissipation of 200W. Table 3.4 outlines the external resistor's Moog part numbers and wire gauge to be used when connecting the regeneration resistor options. Figure 3.25 shows the second option for the external regeneration resistor for the T200-310 unit.

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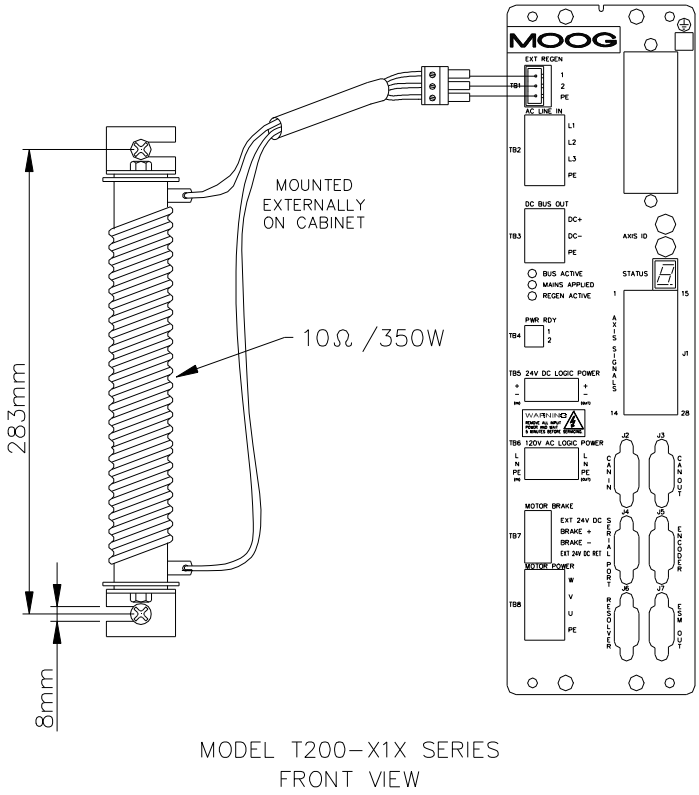

Figure 3.25:- T200-310 Regeneration Resistor 200W Option 2 – A76178-002 (Mounting and Connection)

Regeneration Resistor Option/ Continuous Rating	Actual Continuous Regen. Power	Peak Regen Power	Regen Resistor Kit Part Number	AWG/(mm^2) Wiring to connect regen resistor
50Ohm/55W (Internal)	40W	2.8kW	Already supplied Internally!	No wiring needed
10Ohm/225W (External)	200W	14kW	C22654-002 (US only)	22AWG/ (0.35mm^2)
10Ohm/350W (External)	200W	14kW	A76178-002 (Europe only)	1.5mm^2

Table 3.4:- T200-310 Regeneration Resistor Options

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3.13.2 T200-410 and T200-510 External Regeneration Resistor Connection

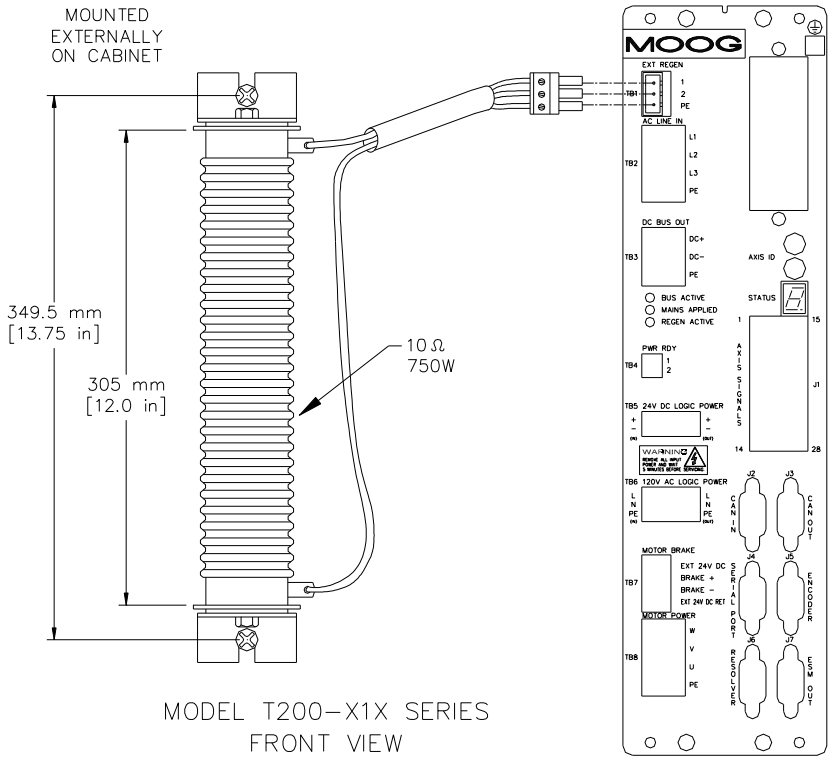

Figure 3.26:- T200-410 and T200-510 600W Regeneration Resistor Option 1 – C22654-006 (Mounting and Connection)

Moog offers two regeneration resitor kit options for use with the T200-410 and T200-510. Figure 3.26 shows the first option for the external regeneration terminal connections for the T200-410 and T200-510 units, which use a 750W-rated resistor operated at a maximum continuous dissipation of 600W. Table 3.5 outlines the external resistor's Moog part numbers and wire gauge to be used when connecting the regeneration resistor options. Figure 3.27 shows the second option for the external regeneration resistor for the T200-410 and T200-510 units.

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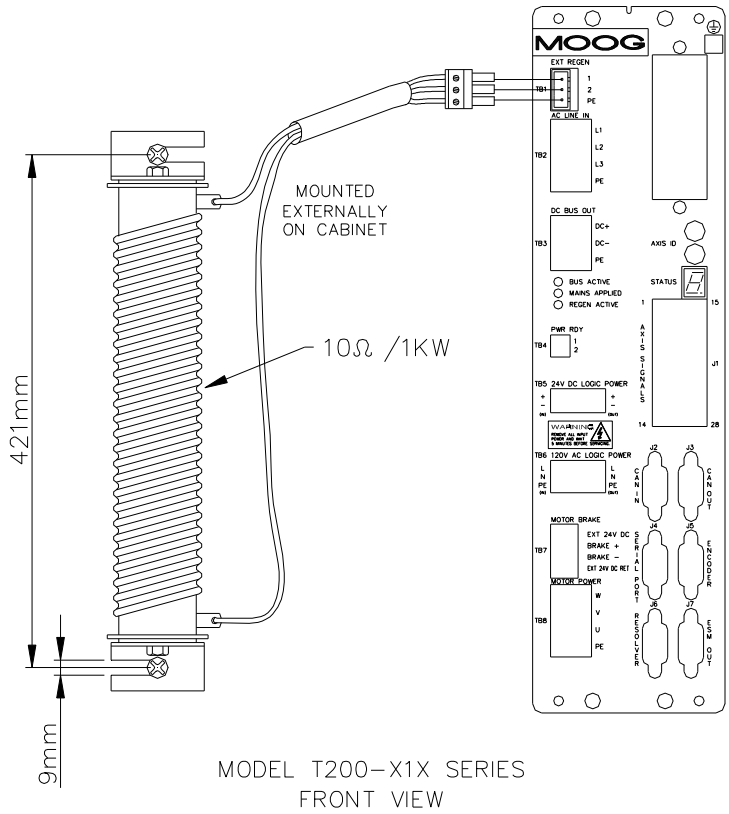

Figure 3.27:- T200-410 and T200-510 600W Regeneration Resistor Option 2 – A76178-003 (Mounting and Connection)

Regeneration Resistor Option/ Continuous Rating	Actual Continuous Regen. Power	Peak Regen Power	Regen Resistor Kit Part Number	AWG/(mm^2) Wiring to connect regen resistor
50Ohm/55W (Internal)	40W	2.8kW	Already supplied Internally!	No wiring needed
10Ohm/750W (External)	600W	14kW	C22654-006 (US only)	20AWG/ (0.60mm^2)
10Ohm/1kW (External)	600W	14kW	A76178-003 (Europe only)	1.50mm^2

Table 3.5:- T200-410 and T200-510 Regeneration Resistor Options

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3.13.3 T200-610 and T200-710 External Regeneration Resistor Connection

MOOG offers four different regen options for the T200-610/710- Figures 3.28 ...3.31 show the different options. Table 3.6 outlines the external resistor's Moog part numbers and wire gauge to be used when connecting these resistors.

The user need to calculate the application dependent regen power and select one of the options accordingly. Options 1..3 are available in the US option 4 is available in Europe. In case of option 4 only one regen resistor can be used if the max. continuous regen power do not exceed 1kW.

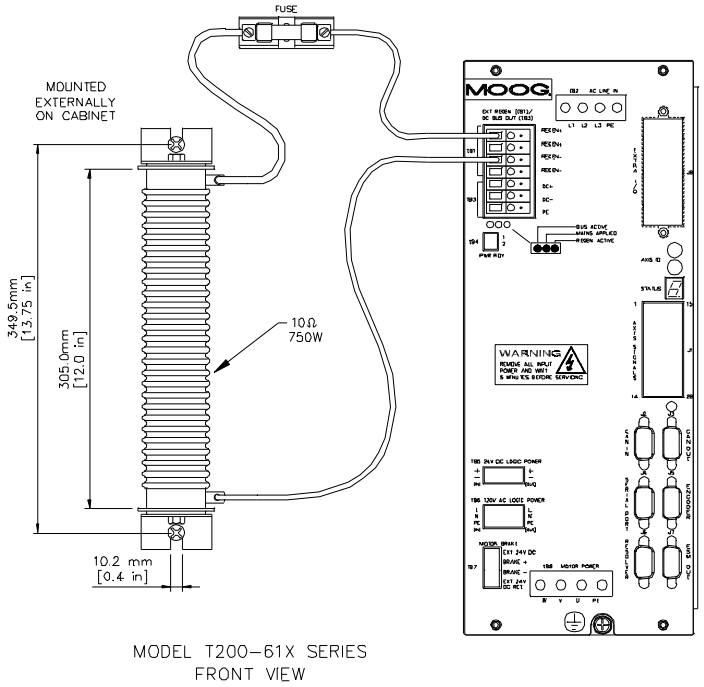

Figure 3.28:- T200-610 and T200-710: 600W Regeneration Resistor Option 1 – C22654-007 (Mounting and Connection)

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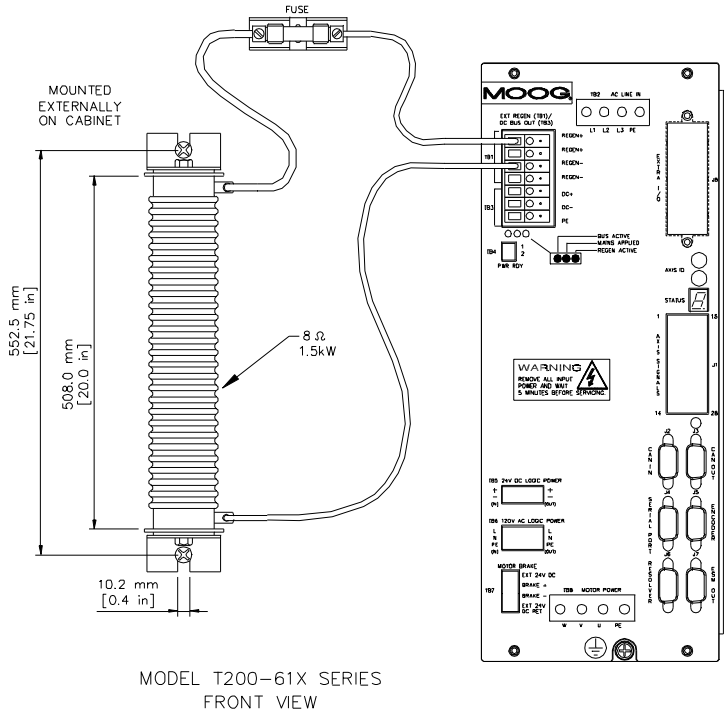

Figure 3.29:- T200-610 and T200-710: 1.25KW Regeneration Resistor Option 2 – C22654-011 (Mounting and Connection)

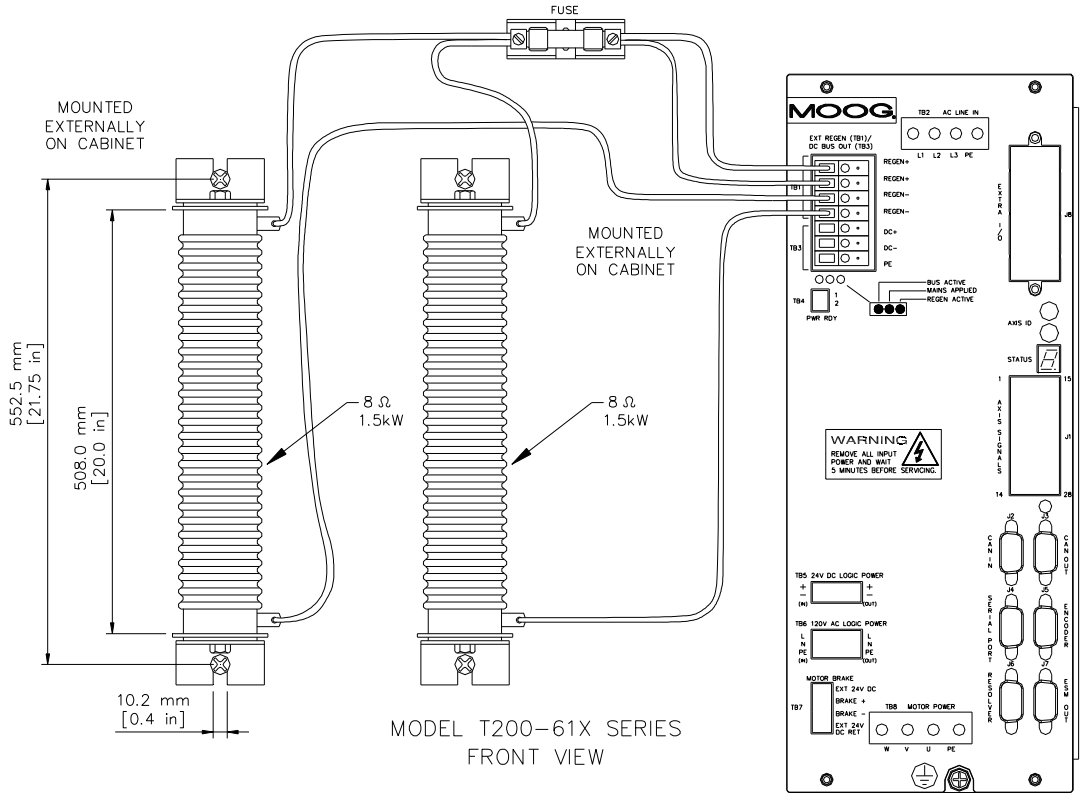

Figure 3.30:- T200-610 and T200-710 Regeneration Resistor Option 3:- C22654-025 (Mounting and Connection)

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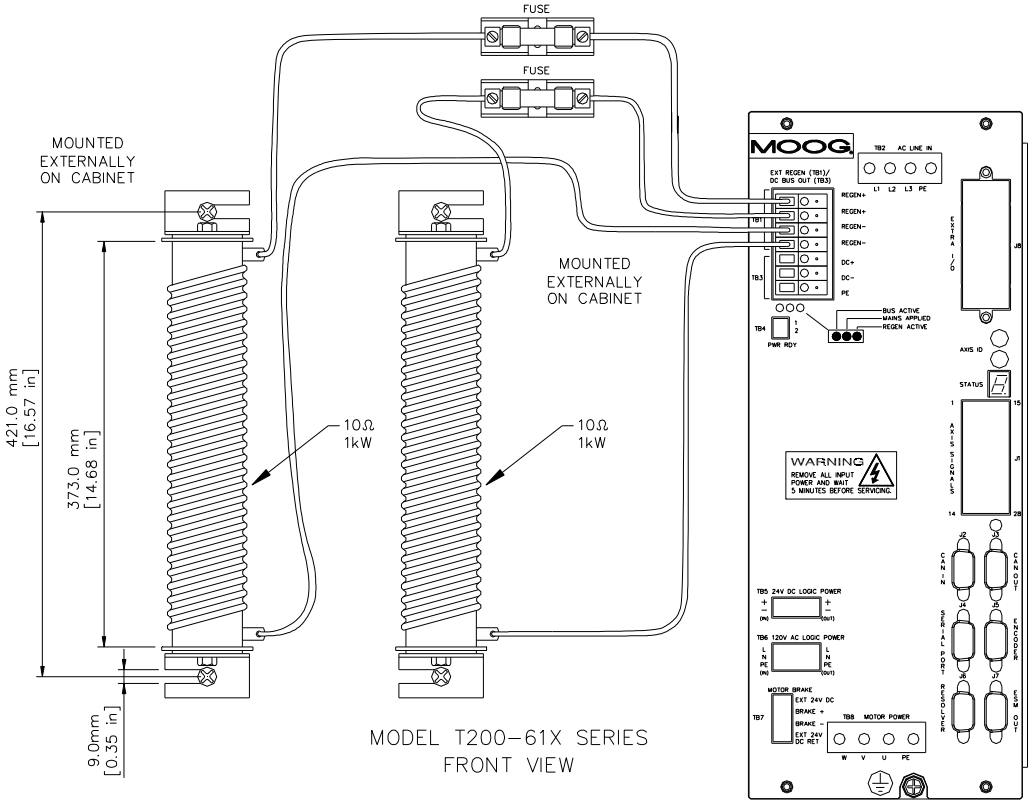

Figure 3.31:- T200-610 and T200-710 Regeneration Resistor Option 4:- two C09838-010 (Mounting and Connection)

Regeneration Resistor Option/ Continuous Rating	**Actual Continuous Regen. Power**	**Peak Regen Power**	**Fuse Part Number**	**Fuse Holder**	**Regen Resistor Part Number**	**Regen Resistor Kit Part Number**	**AWG/(mm²) Wiring to connect regen resistor**
Option 1 (10Ω/750W)	600W	14kW	C09762-012-000	DIN Rail [1)]	B81493-007	C22654-007 (US only)	20AWG/ (0.60mm²)
Option 2 (8Ω/1,5kW)	1,25kW	18kW	C09762-015-000	DIN Rail [1)]	B81493-002	C22654-011 (US only)	14AWG/ (2.0mm²)
Option 3 (Two of 8Ω/ 1.5kW in parallel)	2,5kW	36kW	C09762-025-000	DIN Rail [1)]	B81493-002	C22654-025 (US only)	14AWG/ (2.0mm²)
Option 4 (Two of 10Ω/ 1kW in parallel)	2kW	28kW	C09762-012-000	Fuse Block	A76178-003	Two of C09838-010 (Europe only)	2.5mm²

Table 3.6:- T200-610 and T200-710 Regeneration Resistor Options

[1)] Mechanical dimensions see page 3-55

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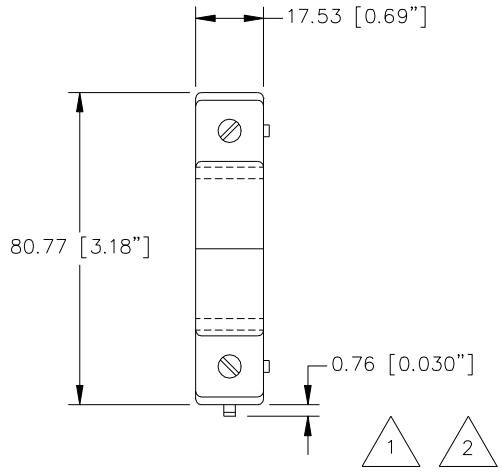

DIN RAIL MOUNTABLE

		Min	Max	
1 WIRE SIZE	AWG	8	18	Cu ONLY
	CSA (mm^2)	0.83	8.4	

2 MAXIMUM TORQUE – 1.36NM [1 lb ft]

Fuse Holder

WARNING - When performing any changes to the regen resistor configuration, a.c. input power must be removed from the T200. Wait 5 minutes upon removal of all power, to allow for D.C. Bus capacitors to discharge. Do not operate the T200 with the cover removed.

WARNING - Operation of the T200 with other than the factory fitted fuse type for the particular regen resistor configuration may cause equipment malfunction and/or damage and may result in the equipment becoming unsafe.

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3.14 Motors - Installation

Motors should be sized by qualified personnel. Improper sizing will directly affect performance and reliability.

Motor performance data for Moog G4XX series is shown in separate data sheets, and in Section 4. Contact Moog Applications Engineering for detailed motor technical information and application sizing, etc.

Standard motors should not be mounted directly onto a gearbox with the shaft inside the lubrication chamber. Motors may be ordered with an optional shaft seal for these applications. When the motor is mounted, the lubricant level within the gearbox must be below the shaft seal of the motor in order to avoid long term seepage and motor failure.

3.14.1 Assembling Motor Resolver and Power Cables

Use of the made-up cable sets is recommended for connecting the MOOG brushless servomotors. These cable sets are available in standardized lengths. Refer to Table 3.7.

If MOOG cables are not used, the values specified below with regard to the cable make-up must be maintained **in all cases**.

Contact your local Moog sales office or authorised distributor for selection of pre-made motor cables.

The following are listed for convenience:-

Europe and Asia
MOOG GmbH
Hanns-Klemm-Strasse 28
71034 Boeblingen
GERMANY
phone: +0049 - 7031 - 622 -0
fax: +0049 - 7031 - 622 - 100

North America
MOOG INC / Industrial Controls Division
Seneca and Jamison Roads
East Aurora, NY 14052
USA
phone: +001 - 716 - 655 - 3000
fax: +001 - 716 - 687 - 4870

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3.14.2 Motor Power Cable

Wire the motor power connector in accordance with Figure 3.32, Figure 3.33, Figure 3.34 and Figure 3.35.

Use wire sizes based on the motor's continuous stall current (r m s) and wire length requirements.

Wiring must be in accordance with standard EN 60204-1 (See Section 2 of this Users Manual.)

For proper drive commutation of G400 series motors, it is required that the motor phase conductors, Phase U (A), Phase V (B), and Phase W(C) be wired exactly as shown in Table 3.7.

3.14.3 T200 Resolver Cable

Wire the motor resolver connector in accordance with Figure 3.35.

NOTE:- Avoid running the resolver cable near other high power wiring, especially the motor power cable, if possible.

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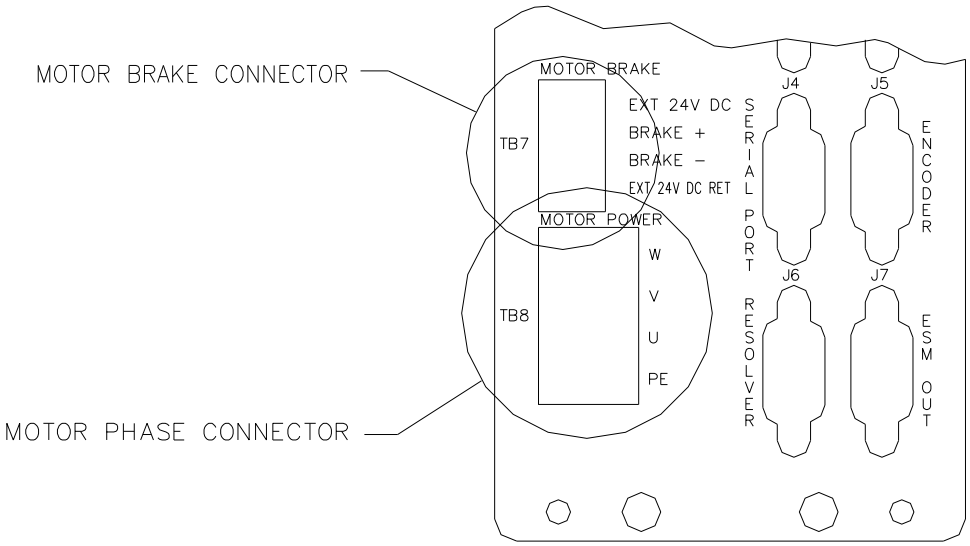

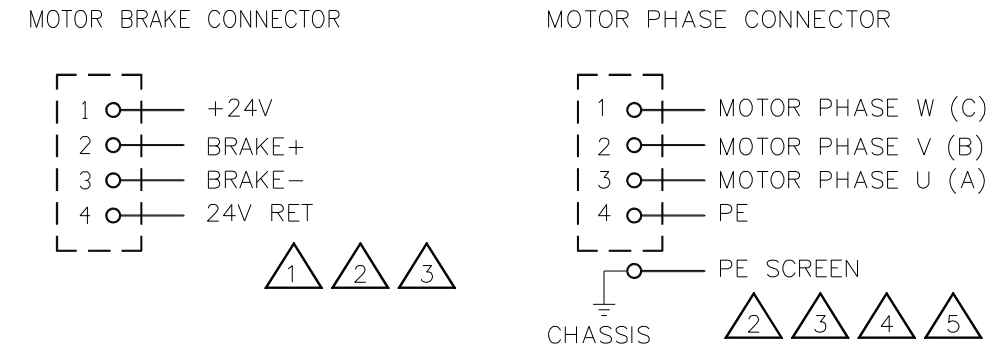

NOTES: –

1. TERMINAL BLOCK WILL ACCEPT 0.2–2.5mm² (12–24 AWG) WIRE.
2. RECOMMENDED STRIPPING LENGTH 7mm.
3. RECOMMENDED TERMINAL SCREW TORQUE 0.55 ± 0.05 Nm.
4. TERMINAL BLOCK WILL ACCEPT 0.2–4mm² (10–24 AWG) WIRE.
5. GROUND PE SCREEN WIRE TO CONTROLLER CHASSIS

Figure 3.32:- T200-3/4/5 Motor and Brake Connections

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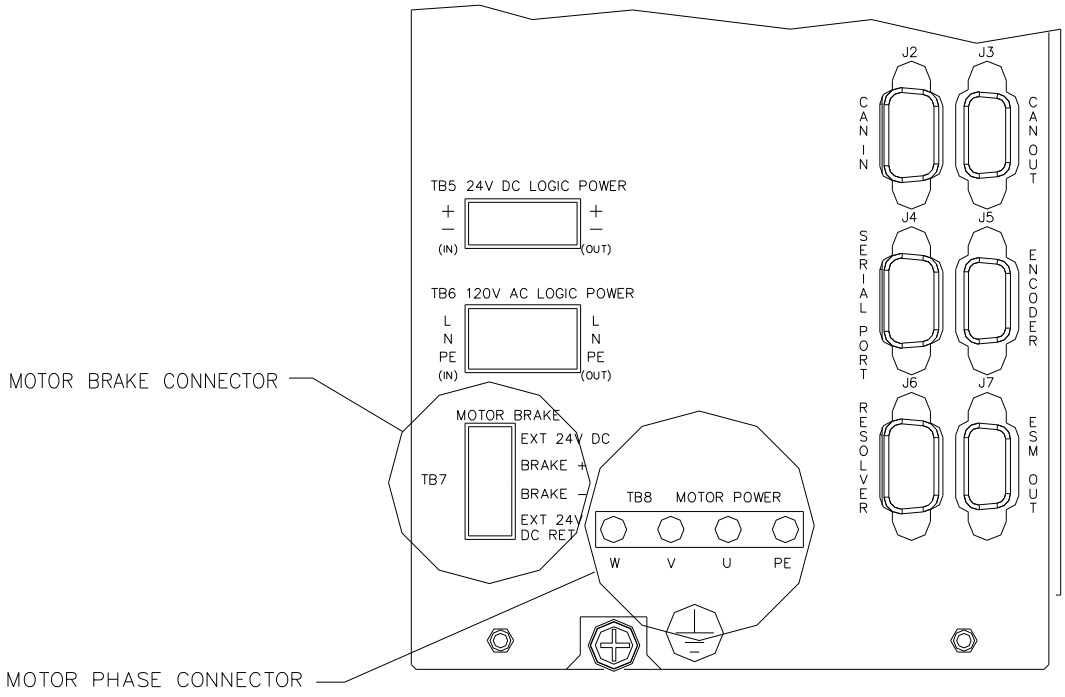

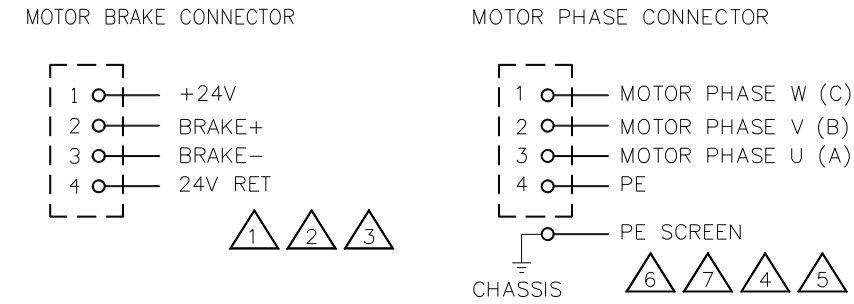

NOTES: –

1. TERMINAL BLOCK WILL ACCEPT 0.2–2.5mm² (12–24 AWG) WIRE.
2. RECOMMENDED STRIPPING LENGTH 7mm.
3. RECOMMENDED TERMINAL SCREW TORQUE 0.55 ± 0.05 Nm.
4. TERMINAL BLOCK WILL ACCEPT 4–16mm² (12–4 AWG) WIRE.
5. GROUND PE SCREEN WIRE TO CONTROLLER CHASSIS
6. RECOMMENDED STRIPPING LENGTH 11mm.
7. TORQUE TO 1.7±0.1Nm.

Figure 3.33:- T200-610 and -710 Motor and Brake Connections

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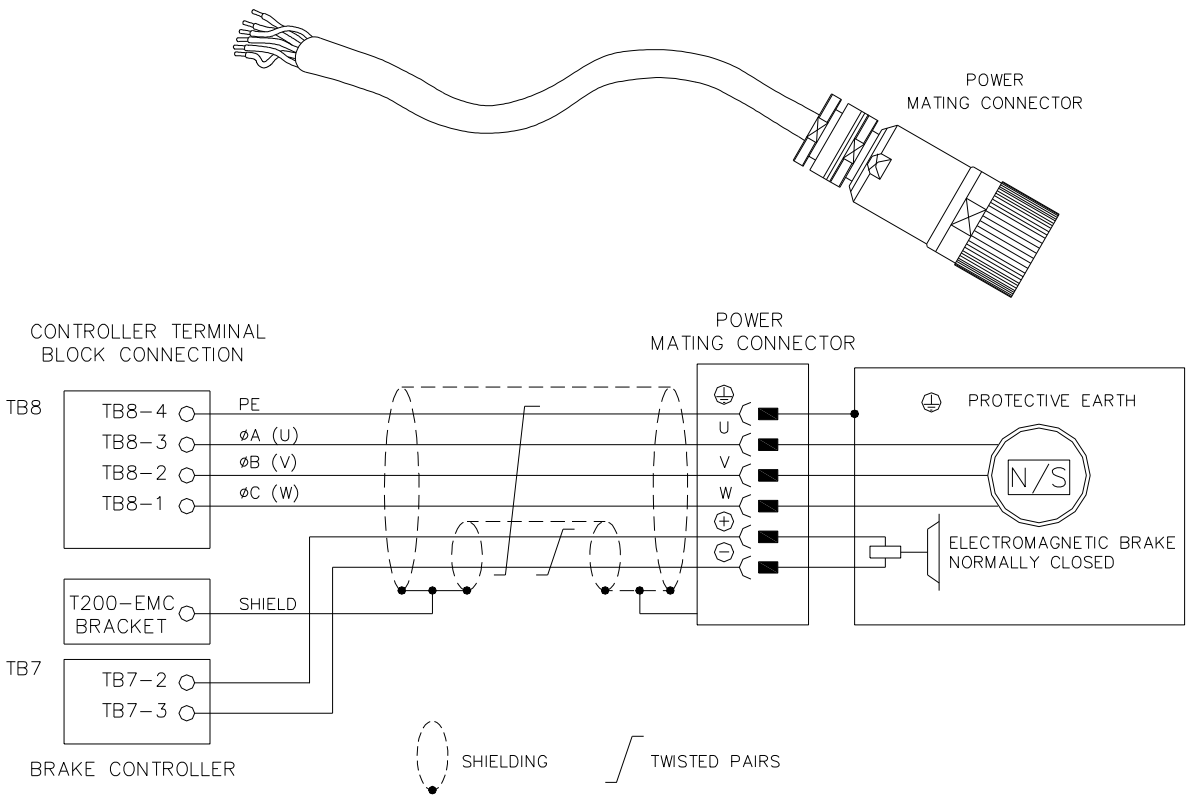

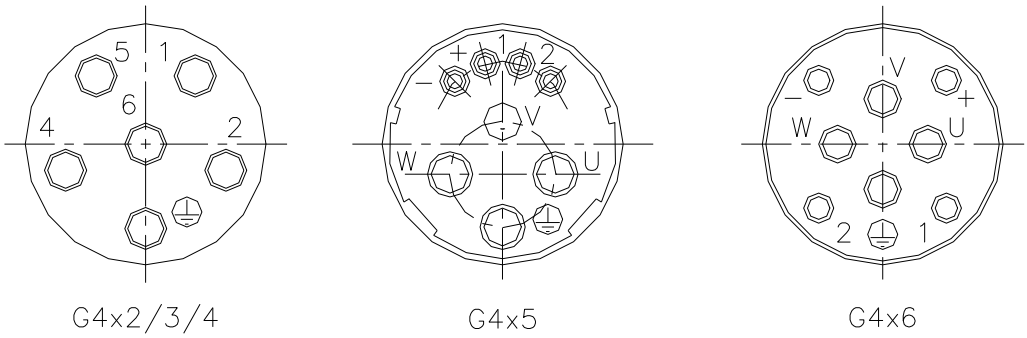

POWER MATING CONNECTOR

T200	G4X2, G4X3 G4X4	G4X5	G4X6
⏚	⏚	⏚	⏚
U	2	U	U
V	4	V	V
W	1	W	W
BRAKE ⊕	5	+	+
BRAKE ⊖	6	–	–

Figure 3.34: Motor Power and Brake Cable

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Pin assignment for Motor Power Cable and Mating Connectors

Bare Cable Layout	Pin Connection		Motor Size	Part Number Power Cables Assembled	Part Number Mating Power Connector loose	Cable Description	Cable Mechanical Specification
B47890-001 12,0 mm *(4x1,5mm²+2x1mm²)*	Phase U Phase V Phase W 24V Brake + 24V Brake - PE	Black U Black VV Black WWW White in separate Shielded Pair Black in separate Shielded Pair Yellow/ Green	G4x2 G4x3 G4x4	B47914-001-xxx ① (Europe only) C22294-001-xxx ① (US only)	A63472-001	4x1.5mm² (AWG 16) Power Lead Wires 2 x 1.0mm² (AWG 17); Brake Wires twisted shielded pair; with overall shield	Designed for use in Cable Tracks and Oil Environment Temperature Range: -50 °C to 90 °C continuous operation 150°C maximum temperature Bending cycles > 5Mio Bend radius for Cable Chain >12 x outer diameter
B47903-001 13,0 mm *(4x2,5mm²+2x1mm²)*	Phase U Phase V Phase W 24V Brake + 24V Brake - PE	Black U Black VV Black WWW White in separate Shielded Pair Black in separate Shielded Pair Yellow/ Green	G4x5	B47915-001-xxx ① (Europe only) C22295-001-xxx ① (US only)	B47736-001	4x2.5mm² (AWG 14) Power Lead Wires; 2x1.0mm² (AWG 17) Brake Wires twisted shielded pair; with overall shield	Designed for use in Cable Tracks and Oil Environment Temperature Range: -50 °C to 90 °C continuous operation 150°C maximum temperature Bending cycles > 5Mio Bend radius for Cable Chain >12 x outer diameter
B47904-001 20,5 mm *(4x10mm²+2x1mm²)*	Phase U Phase V Phase W 24V Brake + 24V Brake - PE	Black U Black VV Black WWW White in separate Shielded Pair Black in separate Shielded Pair Yellow/ Green	G4x6	B47916-001-xxx ① (Europe only) C22296-001-xxx ① (US only)	B47711-001	4x 10mm² (AWG 8) Power Lead Wires; 2x1.0mm² (AWG 17) Brake Wires twisted shielded pair; with overall shield	Designed for use in Cable Tracks and Oil Environment Temperature Range: -50 °C to 90 °C continuous operation 150°C maximum temperature Bending cycles > 5Mio Bend radius for Cable Chain >12 x outer diameter

① -xxx stands for cable length in meter
standard length are -005; -010; -015; -020 (in meters)

Table 3.7:- Motor Power Cable

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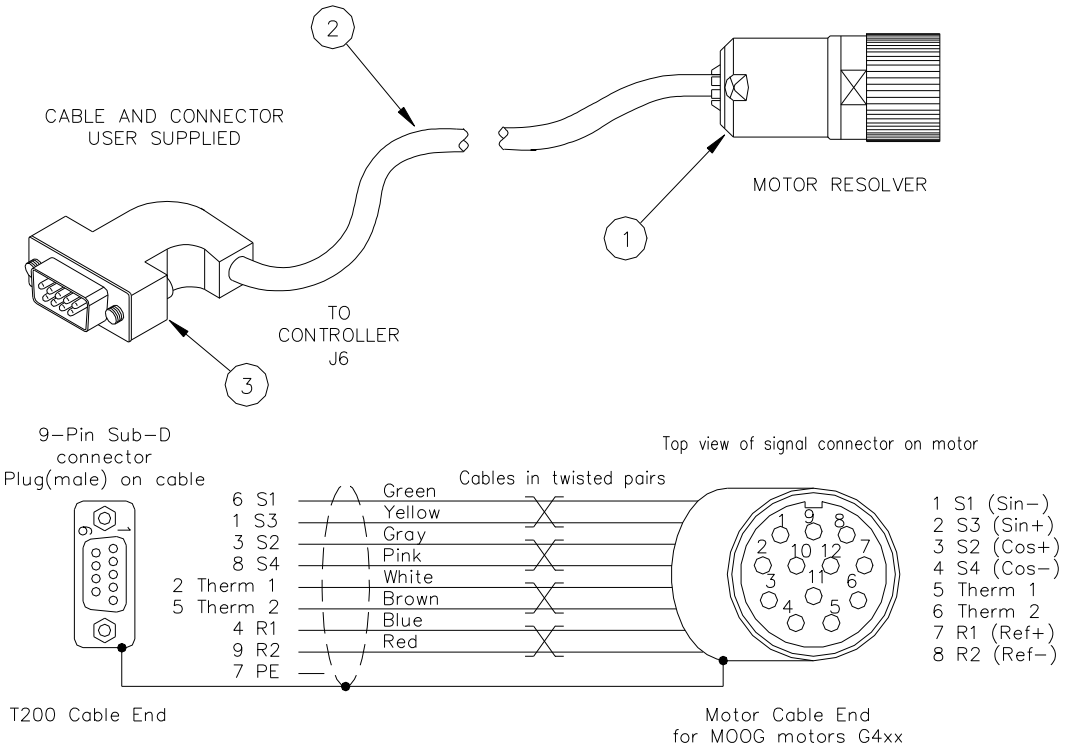

Figure 3.35:- T200 J6 Resolver Cable

Find No.	MOOG Part No.	Description	Quantity
	B47886-001-xxx C22297-001-xxx ①	Complete Cable Assembly	1
1	C08309-001	Signal Mating Connector OD Cable 5,5 mm to 12 mm (.217 in to .472 in) Wire Gauges 0,08 mm^2 to 0.82 mm^2 (AWG 28 to AWG 18)	1
2	B47885-001 ①	Bare Cable	1
3	n.a.	9 Pole Male (Plug) Sub-D:- User Supplied	1

① Refer to Table **3.8** for detailed information

NOTE - 1. Cable Length not to exceed 90 meter (300 ft.)

Required for CE-Compliance

2. For CE-Compliance Shield has to be attached on both sides.

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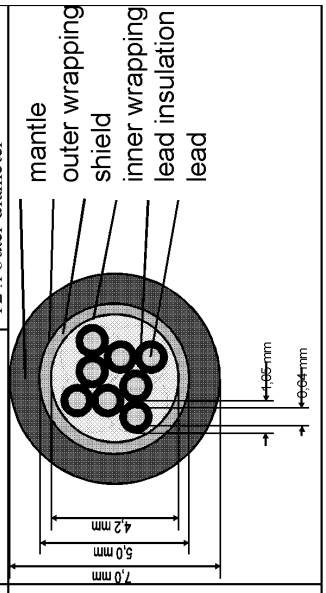
Pin assignment for Motor Signal (Resolver) Cable and Mating Connector

Connector Pin Layout	Pin Connection	Motor Size	Part Number Signal Cables Assembled	Part Number Mating Power Connector loose	Part Number Bare Signal Cable	Resolver Cable Description	Resolver Cable Specification
	1 S1 2 S3 3 S2 4 S4 5 Therm 1 6 Therm 2 7 R1 8 R2 9 n.c. 10 n.c. 11 n.c. 12 n.c.	G4x2 G4x3 G4x4 G4x5 G4x6	B47886-001-xxx ① (Europe only)	C08309-001	B47885-001 (Europe only)	4x2x0.25mm²(AWG24) 4 twisted pairs twisted with overall shield	OD 7 mm (.276 in) Designed for use in Cable Tracks and Oil Environment Temperature Range: -50 C to 90 C continuous operation 150°C maximum temperature Bending cycles > 5Mio Bend radius for Cable Chain >12 x outer diameter
			C22297-001-xxx (US only)		**Cable Wires Cable Colours** Mantle Black 1st Pair White-Brown 2nd Pair Green-yellow 3rd Pair Gray-Pink 4th Pair Blue-Red		

① -xxx stands for cable length in meter. Standard length are -005; -010; -015; -020 (in meters).

Table 3.8:- Motor Resolver Cable

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3.14.4 Crimping Tools for Motor Cables

Contact your local Moog Sales for a detailed specification and Moog Part Numbers for cable/connector crimping tools.

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3.14.5 Terminating the Motor Cable Shield, for CE-Compliance (T200-3/4/5 only)

Required for CE-Compliance

This section should be read by users who require their installation to comply with the EMC-Directive of the EU.

The EMC Brackets shall be used where CE-Compliance under the EMC Directive is required, for the T200-3/4/5 units only. Figure 3.36 below shows how to strip back cabling insulation to expose the shield. Clamp the shield securely under the EMC-Bracket to ensure a good high frequency contact.

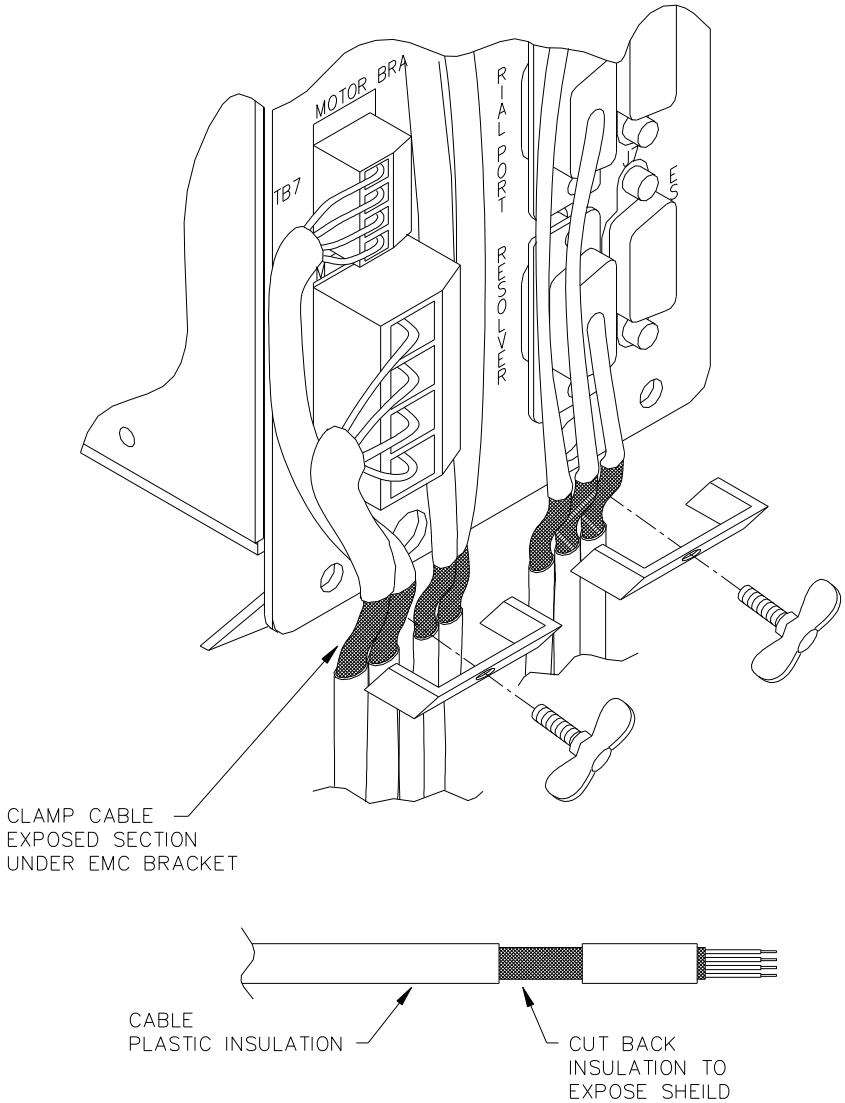

Figure 3.36:- Terminating the Motor Cabling for EMC CE-Compliance

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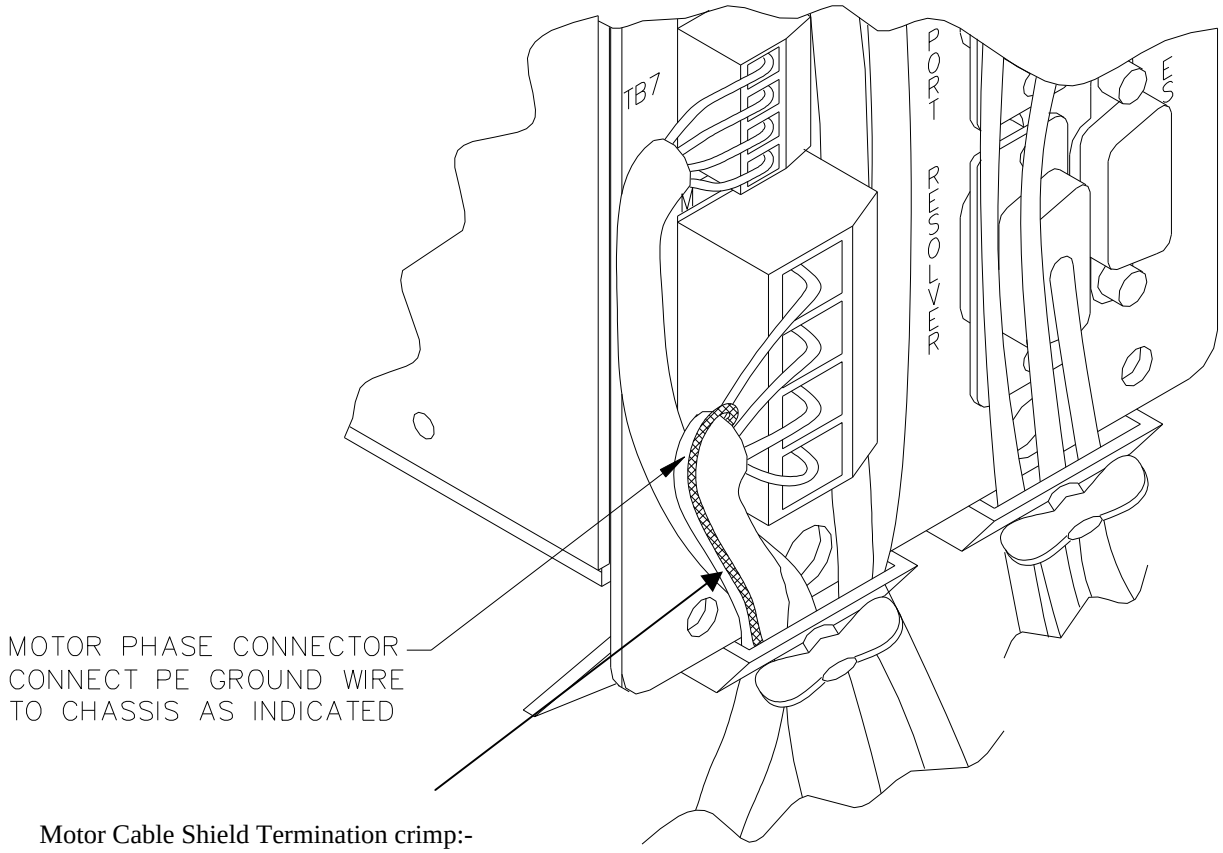
3.14.6 Terminating the Motor Cable Shield (non-CE Applications) T200-3/4/5 only

Moog motor cables are supplied with a terminating crimp for the motor shield. The T200 provides two means of termination of the motor cable shield.

1. The motor cable shield crimp can be screwed into TB8-4 along with the MOTOR-GROUND crimp termination from the motor cable. This is possible with G4x2, G4x3, G4x4 and G4x5 motor power cables.
2. The motor cable shield crimp can be clamped underneath the EMC-bracket as shown in Figure 3.37 below. This is necessary for G4x6 motor power cables. The user must purchase an EMC-Bracket for this purpose, even though he does not require CE-Compliance.



Motor Cable Shield Termination crimp:-
Connect under the EMC Bracket provided.

Figure 3.37:- Attaching the T200 Motor Cable Shield via the Clamp, for a G4x6 motor.

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3.14.7 T200-610 and T200-710 Motor Power Cable Shield Connection

The motor-power-cables shields should be clamped to a suitable Protective Earth bar made available where the cables enter the user cabinet. The connection should be made 360degrees if possible around the cable shield, using P-Clips or other means to ensure good high frequency contact with the Protective Earth

3.14.8 Motor Brake Connection

The T200 provides a motor break relay at connector TB7. The user supplies a 24Vd.c., Power Supply Unit for the brake connections. Note that the current consumption of the different brake types is specified in Section 4.5.7.

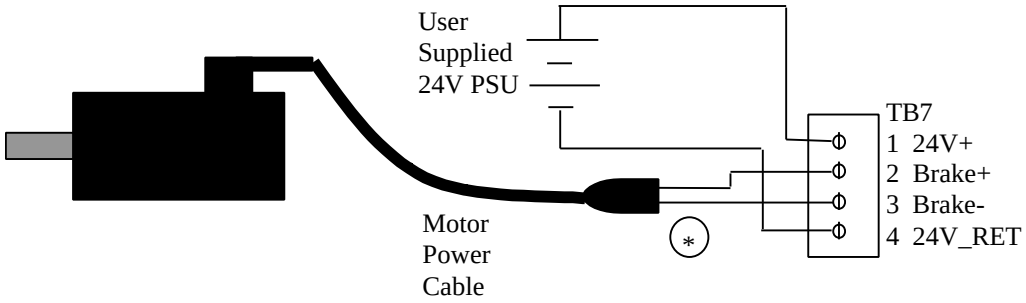

Figure 3.38:- Motor Brake Cabling

* The pins of the brake terminals at the motor cable connector end depend upon the cable size. Refer to Figure 3.34 for details.

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3.15 T200 Control Input and Outputs

The following section contains a description of the control related Input/Output (I/O) available to the user. Functionality is detailed in Section 6.

NOTE - An external 12Vd.c. to 32Vd.c. power source (user supplied) is required for the I/O functions. The amperage rating of this power source will depend on the number of I/O functions used. Supply currents can be calculated as a function of this number and the input and output impedances quoted below.

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3.15.1 General Purpose Description of the Digital Inputs

The following electrical description applies to all the digital inputs of the T200.

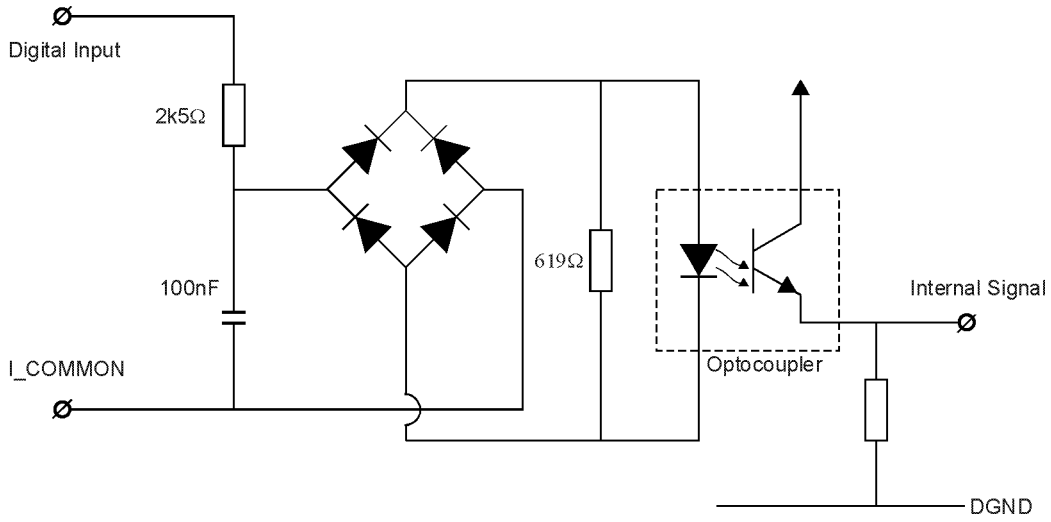

Figure 3.39:- T200 Generic Digital Inputs

Note that:-

- Input Impedance is **2.5k** W.
- Voltage Range is **12V to 32V** from Digital-Input to the I_COMMON line.
  - Input voltages whose magnitude is less than 12V with respect to the I_COMMON line will not be guaranteed to be recognised as an **active** signal input.
  - Input voltages whose magnitude is more than 5V with respect to the I_COMMON line will not be guaranteed to be recognised as an **inactive** signal input
- **All digital inputs are optically isolated** for noise immunity purposes. All T200 digital inputs are isolated from high voltage circuitry internally by double insulation standard isolation, and are considered Safety Extra Low Voltage circuitry.
- **Digital inputs can serve as high side or low side driven**, to cope with a wide variety of digital output formats. For example, I_COMMON can be connected to an external +24V supply, and the Digital Input connected to a pull-down output of a PLC. Alternatively I_COMMON can be connected to an external 24V-RETurn, and the Digital Input connected to a pull-up output of a PLC.

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- Figure 3.40 shows options for connection in pull-up or pull-down mode. Note that all inputs must be used in the same mode for each T200.
- **Current flowing** in the digital input implies the '**safer**' of the corresponding active/inactive functions. For example, when current flows in the clockwise limit switch input, then the limit is NOT active. See Table 3.9.

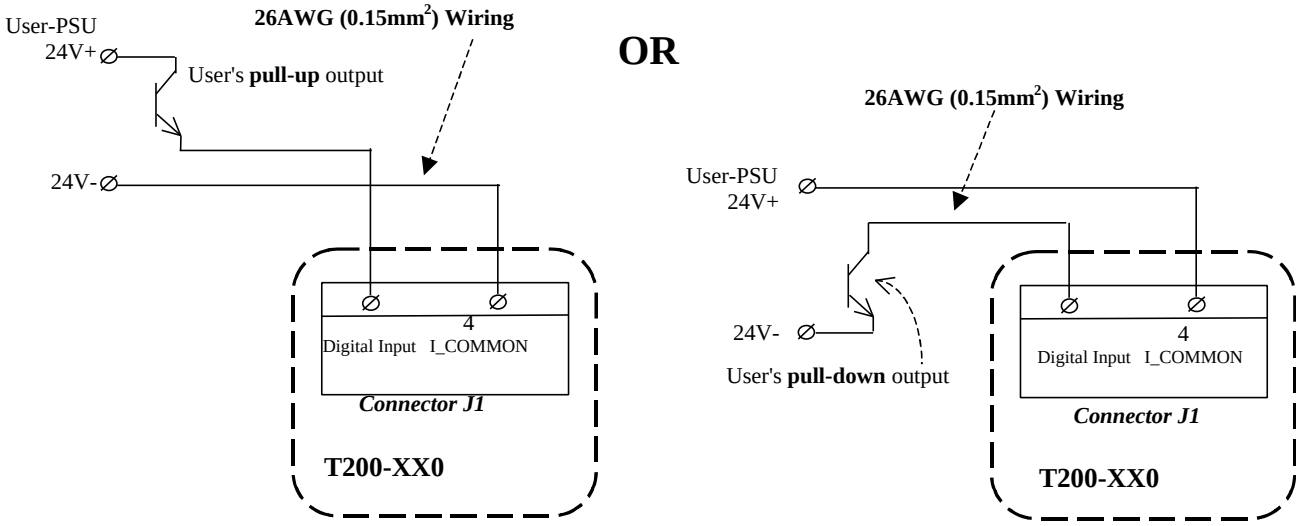

Figure 3.40:- T200 Pull-Up or Pull-Down Options for Digital Inputs on J1

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3.15.2 General Purpose Description of the Digital Outputs

The following electrical description applies to all, except one, of the digital outputs of the T200. (One digital output, SYS-RDY, uses a relay rather than an opto-coupler).

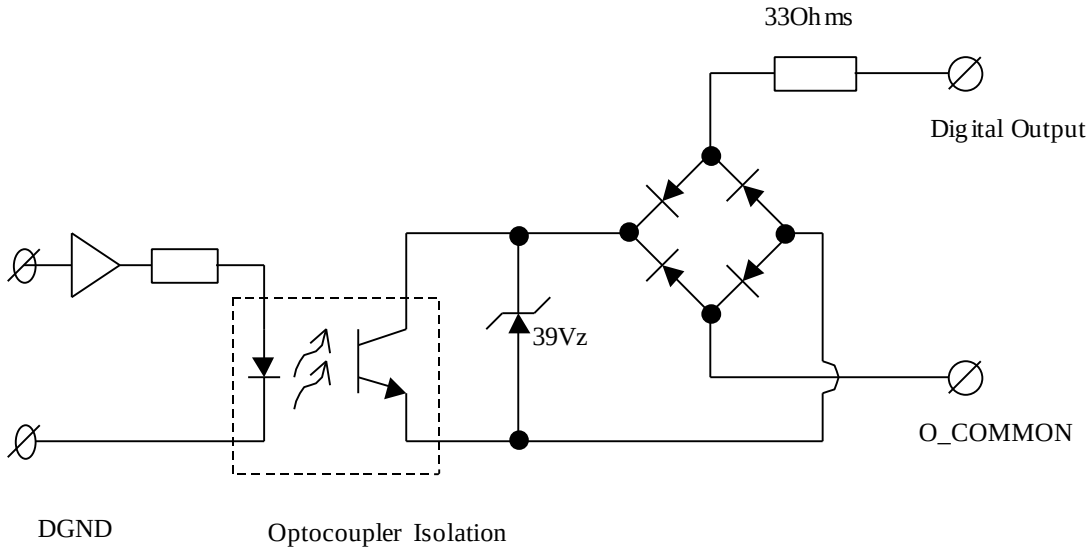

Figure 3.41:- T200 Generic Digital Outputs

Note that:-

- Output Impedance is **33** W.
- Voltage Range is **12V to 36V** from Digital-Output to the O_COMMON line. Digital outputs switch only DC voltages.
- The maximum current carrying capacity is 50mA. The outputs are neither short circuit nor overload protected. The user must ensure that the current is ≤ 50mA.
- **All digital outputs are optically isolated** for noise immunity purposes. All T200 digital outputs are isolated from high voltage circuitry internally by double insulation standard isolation, and are considered Safety Extra Low Voltage circuitry.
- **Digital Outputs can serve as high side or low side drivers**, to cope with a wide variety of digital input formats. For example, O_COMMON can be connected to an external 24V supply, and the Digital Output can pull-up an input of a PLC. Alternatively O_COMMON can be connected to an external 24V RETurn (low voltage side of the 24V PSU), and the Digital Output can pull-down an input of a PLC.
- **Current flowing** in the digital output implies the function is active. For example, when current flows in the DRV_ENABLED output, then the T200 is enabled.

CAUTION:- The circuitry connected to the digital outputs should contain current limiting resistors, so that the maximum current of the T200 outputs is 50mA. The T200 digital outputs will be permanently damaged if the output current exceeds this amount.

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- Figure 3.42 shows options for connection in pull-up or pull-down mode. Note that all outputs must be used in the same mode for each T200.

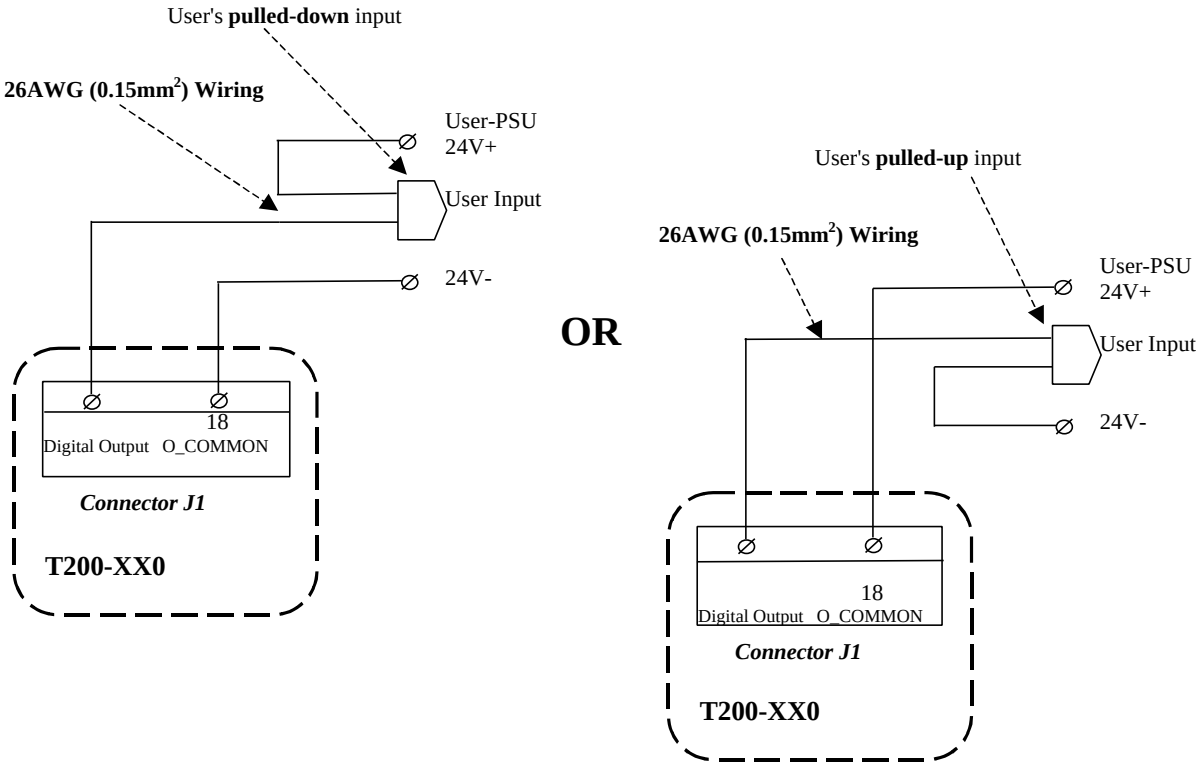

Figure 3.42:- T200 Pull-Up or Pull-Down Options for Digital Outputs on J1

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3.15.3 General Purpose Description of the Analog Inputs

The T200 has two differential analog input stages (Analog-Reference REF± and Spare-Analog-Input SAIN± on connector J1 as shown in Figure 3.45).

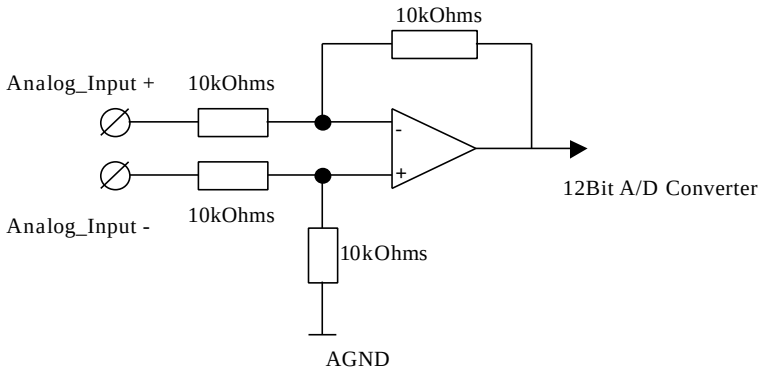

Figure 3.43:- T200 Analog Input Description

Note that:

- Input Impedance is **10k** W.
- Analog input maximum voltages
  Maximum input voltage wrt PE:- 30V.
  Maximum differential voltage:- 30V.
- All T200 analog inputs are isolated from high voltage circuitry internally by double insulation standard isolation, and are considered Safety Extra Low Voltage circuitry.
- A/D Converter resolution is 12bits:- each 4.88mV input voltage step represents 1 conversion bit.
- An approx. 1kHz analog filter is placed before the A/D converter
- Analog Inputs are sampled approximately every 320microseconds to 500microseconds, depending upon the software configuration.

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3.15.4 General Purpose Description of the Analog Outputs

The T200 has two analog output connection points (TP1 and TP2 on connector J1 as shown in Figure 3.45).

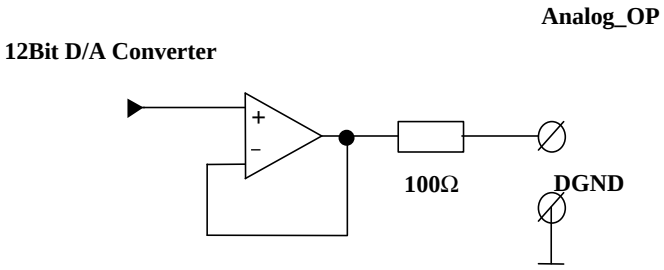

Figure 3.44: T200 Analog Output Description

Note that:

- Output Impedance is **100**W. An internal 100Ω series output resistor is provided in case of output short circuit.
- All T200 analog outputs are isolated from high voltage circuitry internally by double insulation standard isolation, and are considered Safety Extra Low Voltage circuitry.
- D/A Converter resolution is 12bits:- each 4.88mV output voltage step represents 1 conversion bit.
- Analog Outputs are sampled approximately every 320microseconds to 500microseconds, depending upon the software configuration.

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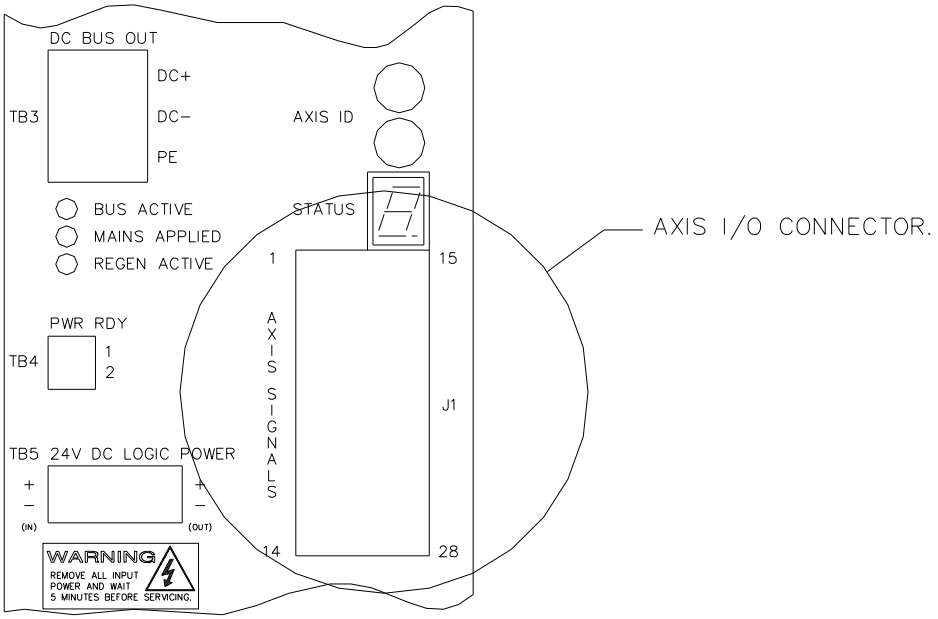

AXIS I/O CONNECTOR.

1	REF+	15	SAIN+
2	REF–	16	SAIN–
3	PE	17	PE
4	I_COMMON	18	O_COMMON
5	ENABLE	19	THRM_LIM
6	PWR_RDY	20	DRV_ENBLD
7	AUTO_MAN	21	SPD/TORQ_ACHVD
8	TRQ_VEL	22	SYS_RDY+
9	CW_LIM	23	SYS_RDY–
10	CCW_LIM	24	TP1
11	BRK_IP	25	TP2
12	ROT_DIR	26	AGND
13	PROG_SPD_1	27	SPARE DIG O/P 1
14	PROG_SPD_0	28	SPARE DIG O/P 2

NOTES: –

1. TERMINAL BLOCK WILL ACCEPT 0.14–1.5mm² (16–28 AWG) WIRE.
2. RECOMMENDED STRIPPING LENGTH 7mm.
3. RECOMMENDED TERMINAL SCREW TORQUE 0.235 ± 0.015 Nm.
4. ACTUAL LAYOUT OF TERMINAL PINS SHOWN.

Figure 3.45: T200 Axis I/O Connector J1

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3.15.5 I/O Overview and Usage in Different Software Modes

Input Name	Analog or Digital	Description	State when active (for digital inputs)	10V Torque or Velocity Analog Reference	Stepper Interface Mode	Digital Inputs Speed Mode	CAN Interpolation Mode Use	CAN Profile Mode Use	Point Mode Alternative Use?
REF±	Analog	±10V Command from the System Motion Controller for torque, velocity or position command	n.a.	REF±	Not used	Not used	Not used	Not used	General purpose analog input
ENABLE	Digital	Enable high power amplifier input command. Cannot enable unless this is active.	Enables when current flows	ENABLE	ENABLE	ENABLE	ENABLE (must be set so that current flows)	ENABLE (must be set so that current flows)	ENABLE (must be set so that current flows)
PWR_RDY	Digital	Indication that the a.c. mains power supply section has soft-started.	Soft-start is complete when current flows	PWR_RDY	PWR_RDY	PWR_RDY	PWR_RDY	PWR_RDY	PWR_RDY
AUTO_MAN	Digital	T200 put in full-power (Automatic) mode or reduced power (Manual) mode	Automatic Mode when current flows	AUTO_MAN	AUTO_MAN	AUTO_MAN	AUTO_MAN	AUTO_MAN	AUTO_MAN
TRQ_VEL	Digital	Commands T200 to switch into torque or velocity mode (only when programmed configuration is already velocity mode)	Torque Mode when current flows	TRQ_VEL	Not used	TRQ_VEL	User defined	Home Switch (see the CAN User Manual for description)	General Purpose Digital Input
CW_LIM	Digital	Clockwise Limit Switch input	Limiting occurs when NO current flows	CW_LIM	CW_LIM	CW_LIM	CW_LIM	CW_LIM	General Purpose Digital Input OR CW_LIM
CCW_LIM	Digital	Counter Clockwise Limit Switch input	Limiting occurs when NO current flows	CCW_LIM	CCW_LIM	CCW_LIM	CCW_LIM	CCW_LIM	General Purpose Digital Input OR CCW_LIM
BRK_IP	Digital	Motor Brake control terminal	Brake is released when current flows	BRK_IP	BRK_IP	BRK_IP	BRK_IP	BRK_IP	General Purpose Digital Input OR BRK_IP
ROT_DIR	Digital	Reverse Direction of rotation of commanded velocity or torque	Reversal from convention when current flows	ROT_DIR	Not used	ROT_DIR	Not used	Not used	General Purpose Digital Input
PROG_SPD_1	Digital	Most significant of two digital velocity command inputs	Speed Programming Table, where 0 implies no current:- 00:- Speed 0 01:- Speed 1 10:- Speed 2 11:- Speed 3	Not used	Not used	PROG_SPD_1	Quick-Stop Input (see the CAN User Manual for description)	Not used	General Purpose Digital Input
PROG_SPD_0	Digital	Least significant of two digital inputs which commands the T200 to rotate at one of 4 programmed speeds, when so configured in software		Not used	Not used	PROG_SPD_0	User defined	Not used	General Purpose Digital Input OR Fast Registration input for Encoder
SAIN±	Analog	0..10V Torque Limit Command from the System Motion Controller	n.a.	SAIN± (Torque Limit)	SAIN± (Torque Limit)	SAIN± (Torque Limit)	Not Used	Not Used	General purpose analog input

Table 3.9:- Overview of T200 Analog and Digital Inputs

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Output Name	Analog or Digital	Description	State when active (for digital outputs)	10V Torque or Velocity Analog Reference	Stepper Interface Mode	Digital Inputs Speed Mode	CAN Interpolation Mode Use	CAN Profile Mode Use	Point Mode Alternative Use?
THRM_LIM	Digital	Thermal limiting has been activated in the drive:- the demand exceeds the current allowed	Current flows when limiting is active	THRM_LIM	THRM_LIM	THRM_LIM	THRM_LIM	THRM_LIM	THRM_LIM
DRV_ENBLD	Digital	Status of the high power being applied to the motor phases	Current flows when power is applied to the motor	DRV_ENBLD	DRV_ENBLD	DRV_ENBLD	DRV_ENBLD	DRV_ENBLD	DRV_ENBLD
SPD/TRQ_ACHVD	Digital	Programmed Speed or Torque Setpoint has been achieved	Current flows when the command-point has been achieved	SPD/TRQ_ACHVD	Position Following Error	SPD/TRQ_ACHVD	SPD/TRQ_ACHVD	SPD/TRQ_ACHVD	General purpose digital output
SYS_RDY±	Digital	Relay output. Status of the fault-state of the T200	Current flows when there are no faults.	SYS_RDY±	SYS_RDY±	SYS_RDY±	SYS_RDY±	SYS_RDY±	SYS_RDY±
TP1	Analog	Test Point analog output	n.a.	TP1	TP1	TP1	TP1	TP1	General purpose analog output
TP2	Analog	Second Test Point analog output	n.a.	TP2	TP2	TP2	TP2	TP2	General purpose analog output
SPARE_DIG_OP_1	Digital	Spare digital output	n.a.	Not Used	Not Used	Not Used	Not Used	Not Used	General purpose digital output
SPARE_DIG_OP_2	Digital	Spare digital output	n.a.	Not Used	Not Used	Not Used	Not Used	Not Used	General purpose digital output

Table 3.10:- Overview of T200 Analog and Digital Outputs

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3.15.6 Power Sequencing on Startup

The timing of the digital inputs ENABLE and PWR_RDY must be considered carefully for proper power-on sequencing.

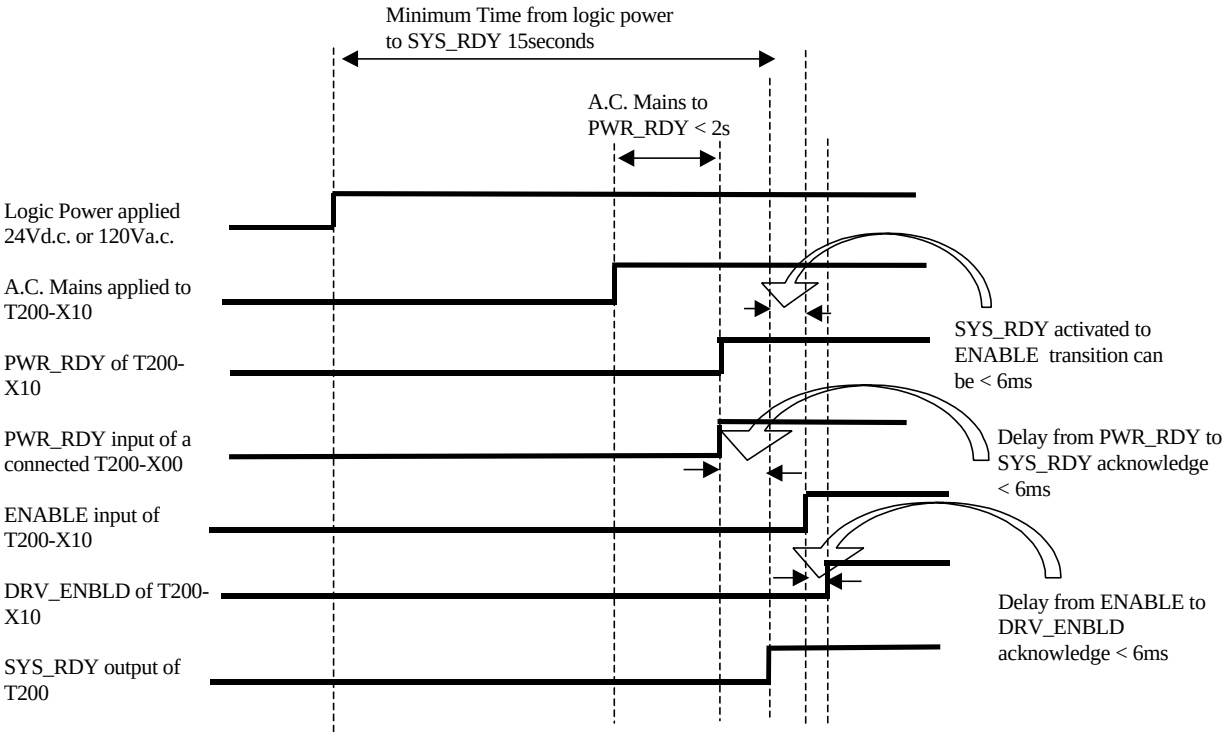
Minimum Time from logic power to SYS_RDY 15seconds
A.C. Mains to PWR_RDY < 2s
Logic Power applied 24Vd.c. or 120Va.c.
A.C. Mains applied to T200-X10
PWR_RDY of T200-X10
PWR_RDY input of a connected T200-X00
ENABLE input of T200-X10
DRV_ENBLD of T200-X10
SYS_RDY output of T200
SYS_RDY activated to ENABLE transition can be < 6ms
Delay from PWR_RDY to SYS_RDY acknowledge < 6ms
Delay from ENABLE to DRV_ENBLD acknowledge < 6ms

Figure 3.46: Power Sequencing control using PWR_RDY and ENABLE

NOTE:- The T200 needs an inactive to active transition on the ENABLE input before it will apply high power to the power amplifier and motor. If a fault is present, and such a transition occurs, the T200 will not enable. A subsequent inactive to active transition MUST occur once the fault has been removed, before the T200 will allow itself to apply high power to the power amplifier and motor.

WARNING - It is UNSAFE to use the SYS_RDY output as a direct control for the ENABLE. The SYS_RDY output will switch off when a software configuration is carried out, and will switch on when the software configuration is complete. This may result in an inadvertent enable of high power to the T200 high power amplifier, resulting in unexpected high voltage application or motion.

The System Motion Controller should examine the state of the SYS_RDY output separately, and then enable the T200 high power amplifier if appropriate

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3.16 Incremental Encoder/Stepper Motor Interface Input Description.

The T200 has an RS422 based incremental encoder input on Connector J5 as shown in Figure 3.49. The same inputs are used for the Stepper Motor inputs.

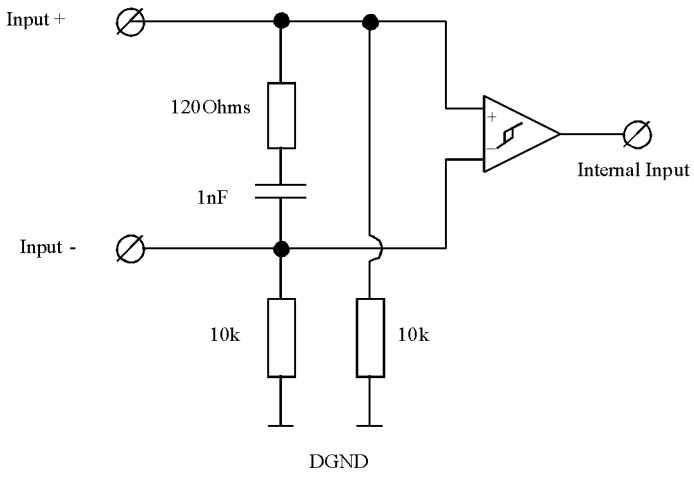

Figure 3.47: Incremental Encoder per channel Input Electrical Description

- **Input Impedance is 120W in series with a 1nF capacitor**, to reduce driver power losses. A 10k resistor also connects each input to Digital Ground (DGND).
- **Expected signal levels on the inputs are 0-5V differential**.
- **A 5V power output line is provided to power the incremental encoder**. The output power supply 5V line has a 100mA-continuous fuse which will open-circuit if the current exceeds 300mA. Note that the fuse is resetable.
- Maximum input voltages: 25V Input+ to Input- differential
  25V Input± to DGND or T200 PE connection
- All T200 inputs are isolated from high voltage circuitry internally by double insulation standard isolation, and are considered Safety Extra Low Voltage.
- The Internal Inputs are fed to fast internal digital circuitry, which further digital filters these inputs to remove high speed glitches which have passed through the differential amplifier.
- **Up to 1MHz input pulse rate**.

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3.17 Encoder Simulation Output Description

The T200 has an RS422 based incremental encoder simulation output on connector J7 as shown in Figure 3.49.

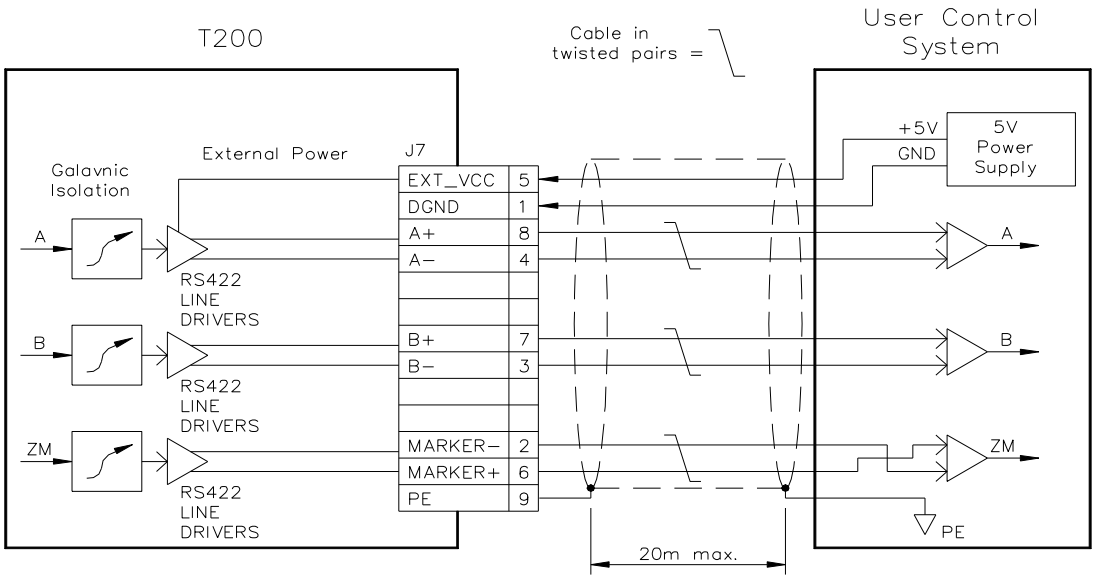

Figure 3.48: Encoder Simulation Output Electrical Description

- **Galvanically isolated drivers must be supplied by a User-Supplied 5Vd.c**..
- **5V Current demand is up to 80mA per axis** for the isolated circuitry and output drivers stage.
- **Signal levels on the outputs are 0-5V differential**.
- Output drivers can withstand short to 5V or User-DGND for up to 1second.
- All outputs are isolated from high voltage circuitry internally by double insulation standard isolation, and are considered Safety Extra Low Voltage circuitry.
- **Recommended Cable is Belden 9891 or equivalent.**
- **Maximum recommended cable length is 20m.**

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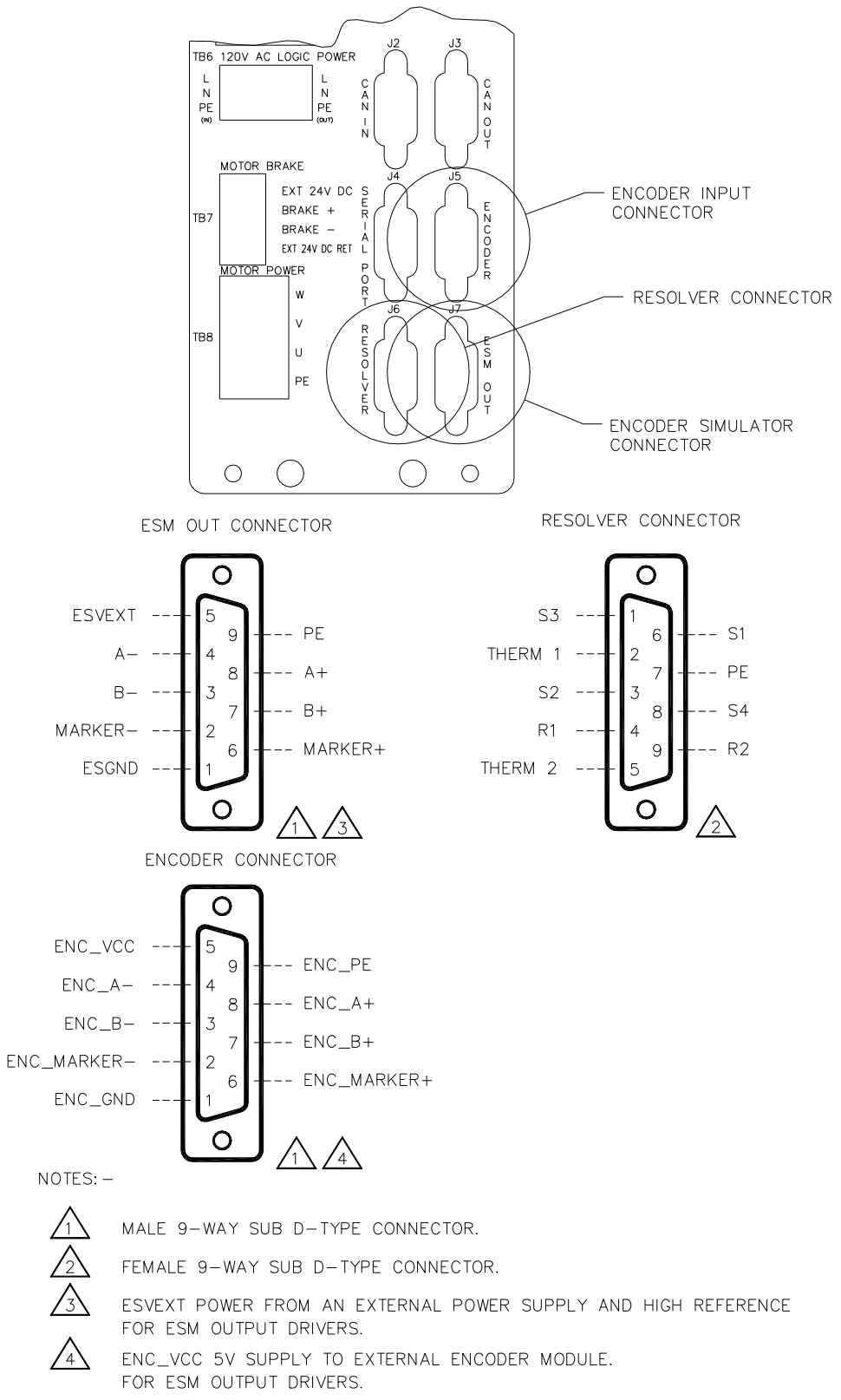

Figure 3.49: T200 Position Transducer Interfaces

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3.18 Communications Interface Wiring and Configuration

The T200 provides three serial communications interfaces:-

1. RS232 for communications between one System Motion Controller and one T200
2. RS485 for communications between one System Motion Controller and many T200's
3. CAN for higher bandwidth communications between one System Motion Controller and many T200's (which can handle motion commands between the System Motion Controller and T200's)

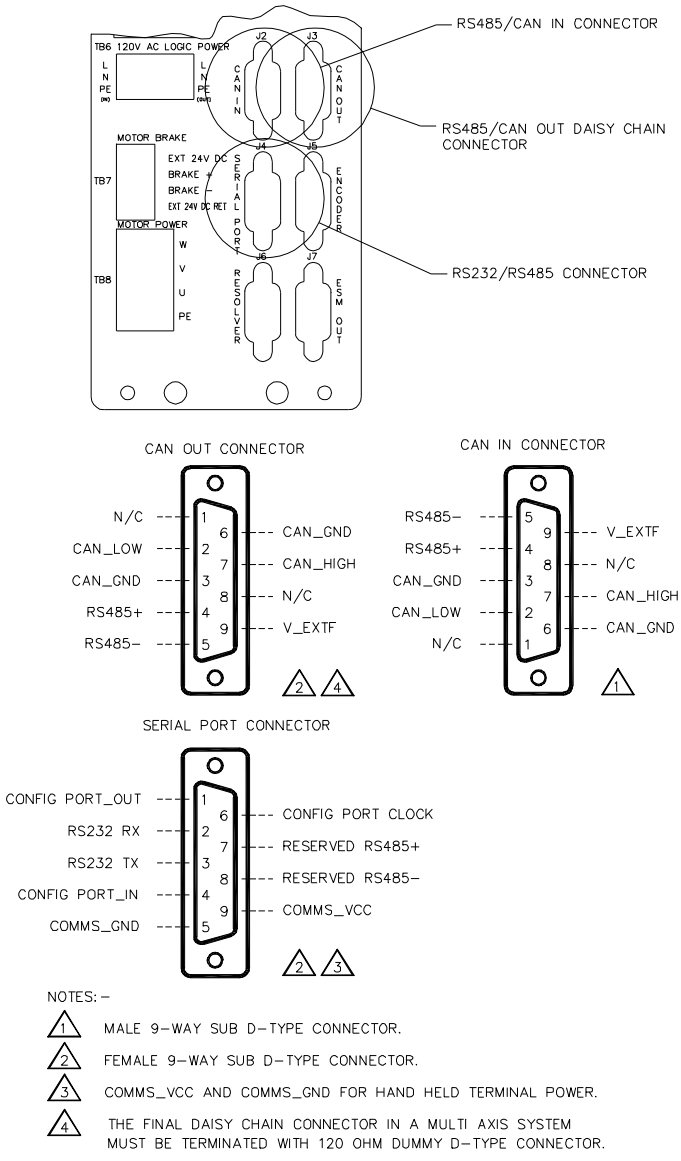

Figure 3.50: T200 Communications Terminals

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3.18.1 RS232 Interface Description

The T200 provides an RS232 compatible communications interface on J4 (9-Sub-D Female (Socket) on the T200 side). The RS232 port provides a one to one communication mechanism only.

3.18.1.1 Wiring an RS232 Connection

The RS232 port of the drive is configured as a null modem. The connector pins on the Serial Port 9-way D-Type connector on the front-panel of the servo-drive are as follows:-.

Pin Number	Function
1	Reserved for future use
2	**RS232 Receive Rx**
3	**RS232 Transmit Tx**
4	Reserved for future use
5	**GND**
6	Reserved for future use
7	Reserved for future use
8	Reserved for future use
9	**5V Supply for Hand Held Terminal**

Table 3.11:- T200's RS232 Pinout on J4

The diagrams below show the wiring required for an RS232 cable between a PC (typically with a modem com port) and T200 servo-drive.

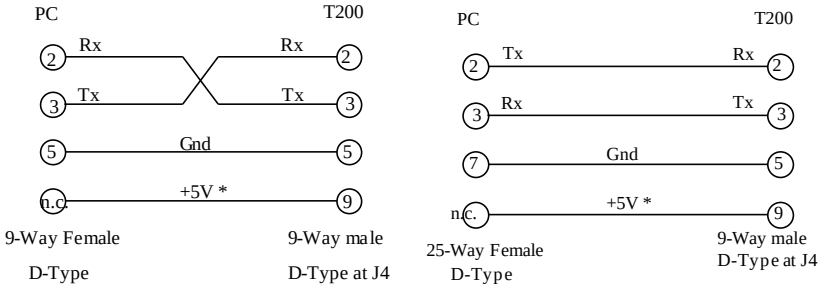

Figure 3.51: T200's J4 RS232 Wire Pin-out (to 9-Way and 25-Way Connectors)

* The +5V line is not used when connecting to a P.C. However it can be used to power a Hand Held Terminal Device.

NOTE:- The +5V line on J4 is rated to operate at 100mA. If the current exceeds this amount then a resetable fuse will open. When the excessive current drain is removed, then the +5V line will be able to source current again.

The RS232 Cable shield should be connected to the metal body of the D-Type connector.

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3.18.1.2 RS232 Set-up Parameters

The following port parameters are used to communicate with the T200 via the RS232 link:-

- 9600 baud
- 8 data bits
- 1 stop bit
- no parity bits
- no hardware control/handshaking.

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3.18.2 RS485 Interfaces Description

The T200 provides an RS485 compatible communications interface on J2 and J3 (9-Sub-D Male and Female (Connector and Socket) on the T200 side). The RS485 port provides one to many communications. Two Sub-D connectors are provided to allow convenient daisy-chain connection of the RS485 cabling from one T200 to the next.

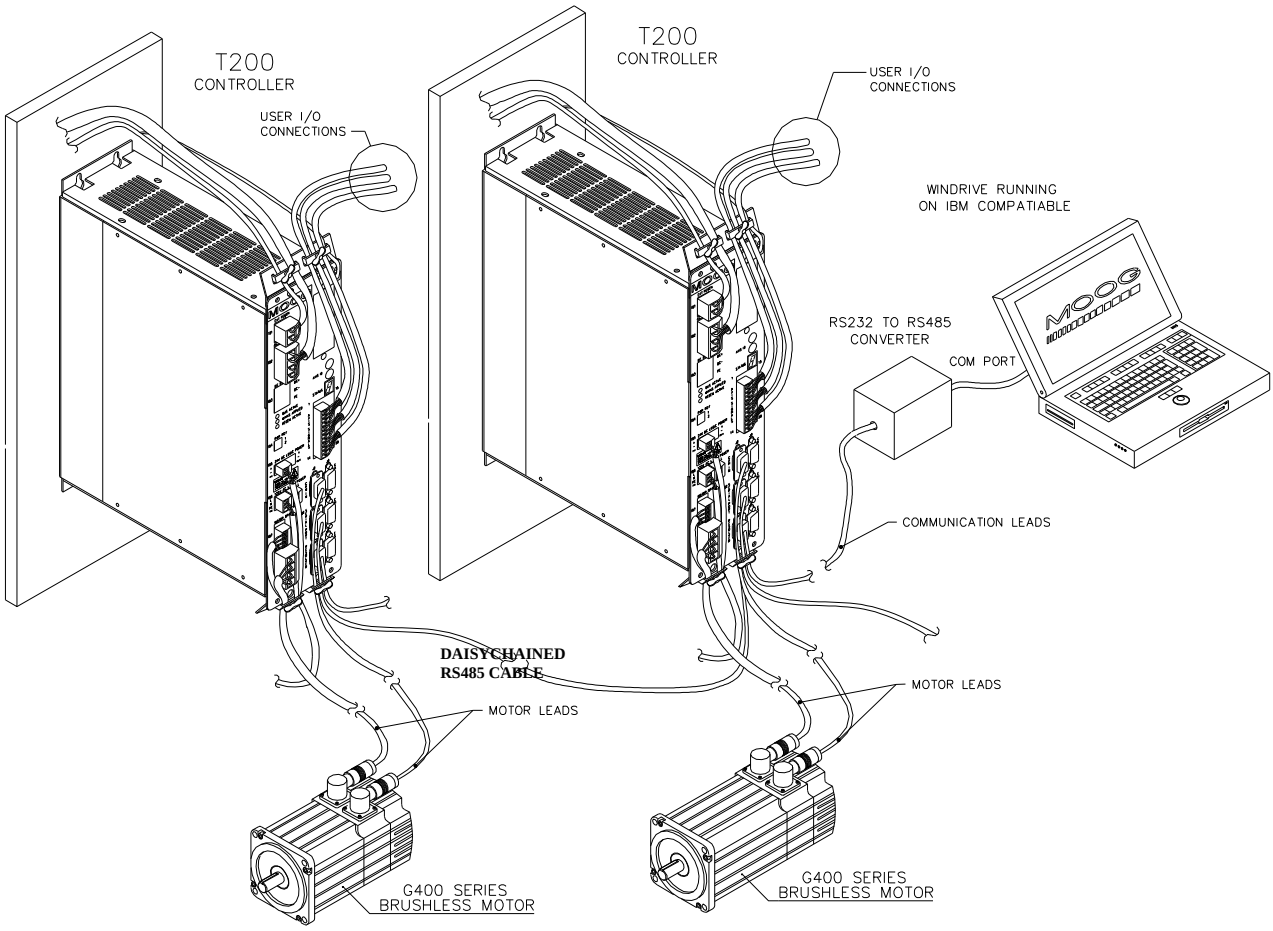

Figure 3.52: T200 Multi-Axis RS485 System

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3.18.2.1 Wiring an RS485 Connection

The connector pins on the Serial Port 9-way D-Type connectors on the front-panel of the drive are as follows:-

Pin Number	Function
1	Reserved for future use
2	CAN-Low
3	CAN_GND
4	**RS485+**
5	**RS485-**
6	CAN_GND
7	CAN_High
8	DGND
9	V_EXTF

Table 3.12:- T200's RS485 Pinout on J2 and J3 (Same Pinout on both Connectors)

CAUTION:- The RS485 Cable shield MUST be connected to the metal body of the D-Type connector, in order to provide a good galvanic connection between the host computer and the T200 local signal ground. If this is not done then RS485 communications may be subject to spurious interruptions.

3.18.2.2 RS485 Adaptor for Conversion of RS232 to RS485

Recommended RS485 communication from a PC to a group of T200's is achieved by using an RS232/RS485 converter. The RS232 side of the converter is connected to the selected communications port of the PC. The RS485 side of the converter is connected to the drive via the RS485 port (J2) of the T200.

RS485 communication is achieved by interfacing a suitable RS232/RS485 adaptor between the PC and drive. See Section 7 for recommendations on installing an RS485 interface with the WinDrive user interface

Adaptor Requirements
The following adaptor and cable requirements should be met by any adaptor that is used with Moog's WinDrive user interface.

- Half Duplex Operation (Data Signals are both transmitted and received on two pairs wired in parallel (i.e. Tx/Rx (A) = RS485+, and Tx/Rx (B) = RS485-).
- Method of Enabling of Transmitter of adaptor from the P.C. (e.g. use TxData line to enable adaptor transmission on the RS485 line).
- Tx+ and Tx- Pull up/down resistors, (values depend on Adaptor used.).
- Screened twisted pair (nominal impedance 120 W).
- Cable end termination with user supplied 120Ω resistors.

In Half Duplex operation, the RS485 side of the adaptor must be able to enable its transmitter when the adaptor is ready to transmit, and disable (i.e. tri-state) the transmitter when the adaptor is ready to receive. Some adaptors use the RTS line from a PC' communications port as an enable signal to the transmitter. Other adaptors will implement the enabling of the transmitter internally.

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Example of PC Interface

If an external signal is required to enable the transmitter of the adaptor, the Transmit Data pin from the PC can be used as an enable pin. An adaptor can be wired to ensure that the transmitter is enabled when data is sent, thus actively driving Highs on the RS485+ line.

If the RTS line is used by the adaptor, the following adaptor can be placed between the PC Communications port, and the RS232/485 Converter. WinDrive uses only the Transmit Data, Receive Data, and Signal Ground Pins on the PC Communications port.

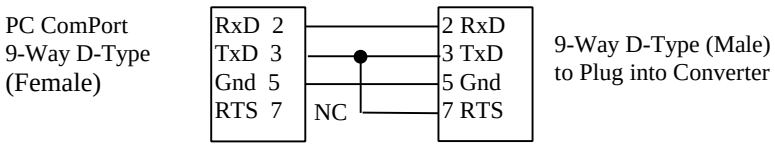

Figure 3.53:- Adaptor between PC and RS232/RS485 Adaptor

For details of wiring for a specific RS232/RS485 adaptor, consult the data-sheet for the particular device. The RS232/RS485 Adaptor recommended by MOOG for operation with WinDrive and the RMC/DMC and T200 is PSM-EG-RS232/RS485-P/2D, PN2761392 from Phoenix Contact.

PC COM PORT	SIGNAL	PHOENIX RS232	
		9-PIN D	COMBICON
1	SHLD	NC	NC
2	RXD	2	5
3	TXD-RTS	3 & 7	4 & 7
5	GND	5	8

T200 RS485	SIGNAL	PHOENIX RS485	
		9-PIN D	COMBICON
4	RS485 +	3	6
5	RS485 -	8	8
6	GND	2 - 7	4

Table 3.13:- Wiring of PSM-EG-RS232/RS485-P/2D

For further information consult MOOG applications engineering.

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3.18.2.3 RS485 Line Termination

RS485 lines must be terminated in 120Ohm resistance, at each end of the cable, between the positive and negative terminals (RS485+ and RS485-). Figure 3.54 below does not show a 120 Ω resistor at the adaptor end as this is presumed to be part of the adaptor circuitry.

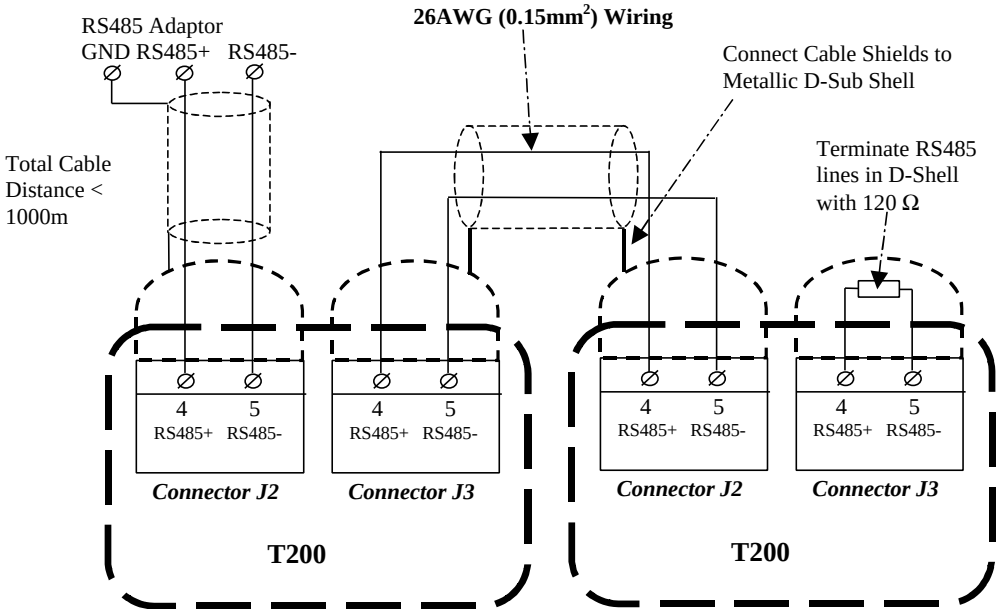

Figure 3.54:- RS485 Wiring and Termination

3.18.2.4 RS485 Cable Maximum Length

The maximum combined length of all RS485 cabling is 1000m. Combined length is the sum of all cable segments, including the cable from the RS485 adaptor to the first T200, and between subsequent T200's and the next, and so on to the end of the cable.

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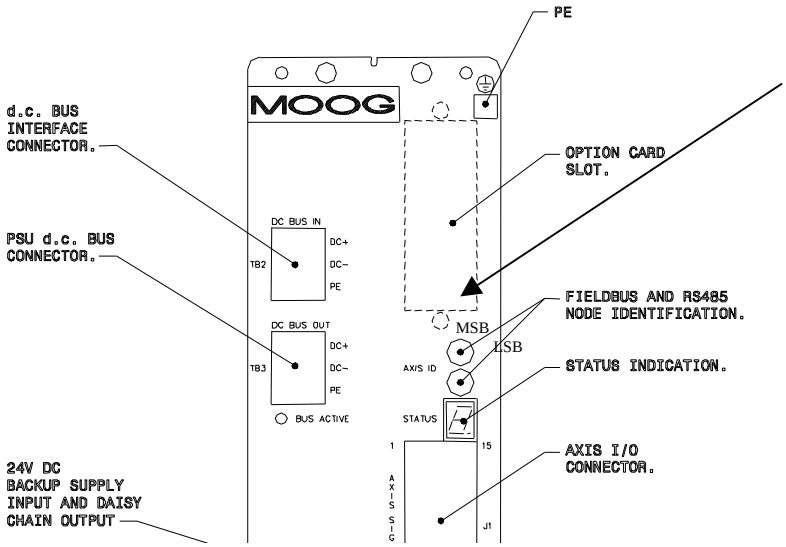
3.18.2.5 RS485 Address Set-up via Axis-ID-HEX-Switches on T200 front Panel

A unique RS485 address must be assigned to each T200 in an RS485 network. The two Node ID switches are used to set this address. Note that a fine screwdriver should be used to set the HEX switches to the appropriate value. Node addresses start at 1, rather than 0. The node address 0 is reserved for broadcast messages via RS485.

Figure 3.55:- Axis ID HEX Switches Location



The T200 has two HEX (modulo-16) Switches that should be set to the axis identification number of the T200. Modulo-16 means that the number range that can be selected is from 0 to 15. Numbers in the range 10 to 15 are represented by A to F. For example, to set the axis identification number to 29, the top switch should be set to 1 and the bottom switch to D, since:-

29 = 16 by 1 plus 13

and

13 = D in the modulo 16 representation.

These switches are located on the front panel of the T200 and are accessible without opening the T200. The upper most of the two switches is the most significant.

3.18.2.6 RS485 Set-up Parameters

The following port parameter settings are used to communicate with the T200 via the RS485 link:-

- 9600 baud
- 8 data bits
- 1 stop bit
- no parity bits
- no hardware control/handshaking.

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3.19 T200 User Visual Indications

The T200 product family provides the following diagnostic information to the user:-

- On T200-X10 models (with integral High Power PSU), three power monitoring LED's are provided for user diagnostic purposes (BUS ACTIVE, MAINS APPLIED, REGEN ACTIVE in Figure 3.56).
- On T200-X00 models (without integral High Power PSU), one power monitoring LED is provided for user diagnostic purposes (BUS ACTIVE in Figure 3.57).
- On all models a 7-segment display is provided to display user diagnostic information.

LED Name	Color	Description of Operation
BUS ACTIVE	Green	Illuminates when high voltage is present on the T200 DC Bus terminals (on connector TB3)
MAINS APPLIED	Amber	Illuminates when A.C. Mains is applied (on connector TB2)
REGEN ACTIVE	Amber	Illuminates when motor kinetic energy regeneration is active (voltage applied via connector TB1)

7-Segment Display User Indication Codes

The appropriate characters of the code will appear at about 0.5 second intervals. Fault conditions will be displayed as the highest priority, followed by abnormal conditions (warnings) and then normal operation codes.

Normal Operation Display	
U1	AC Mains high power is not applied
P	T200 is self-parameterisating.
O	Indicates that no faults are present and the drive is powered correctly.
E	High power is presently applied to the motor phases (i.e T200 is enabled).

Abnormal Condition Display	
[.]	The period indicates that servo-drive current levels have been limited due to thermal self protection reasons.
E2/U2	Motor temperature has exceeded 130°C.
E3/U3	Bridge temperature has exceeded a defined warning threshold.
E4/U4	Position Following Error occurring.
E5/U5	Velocity Following Error occurring.
E6/U6	The continuous rating of the external regeneration resistor has been exceeded.
E7/U7	Servo-drive Controller Area Network (CAN) communications error.
E8/U8	Limit switches have been activated.
U9	Internal software programming error.
Ua	Quick-Stop function active.
Ub	Incremental Encoder has been disconnected.

Fault Condition Display	
F1	Power Amplifier over-current fault has occurred.
F2	DC-Bus voltage has exceeded 400V.
F3	Only for T200-X10 models, the internal regeneration circuitry fuse has blown.
F4	Only for T200-X10 models, the rectifier heat-sink temperature is too high.
F5	The Temperature of the Power Amplifier heat-sink is too high.
F6	The Temperature of the motor has exceeded 155°C.
F7	Fatal programming error or critical software error has occurred.
F8	Resolver position transducer error has occurred.
F9	Internal ±15V control voltage loss.

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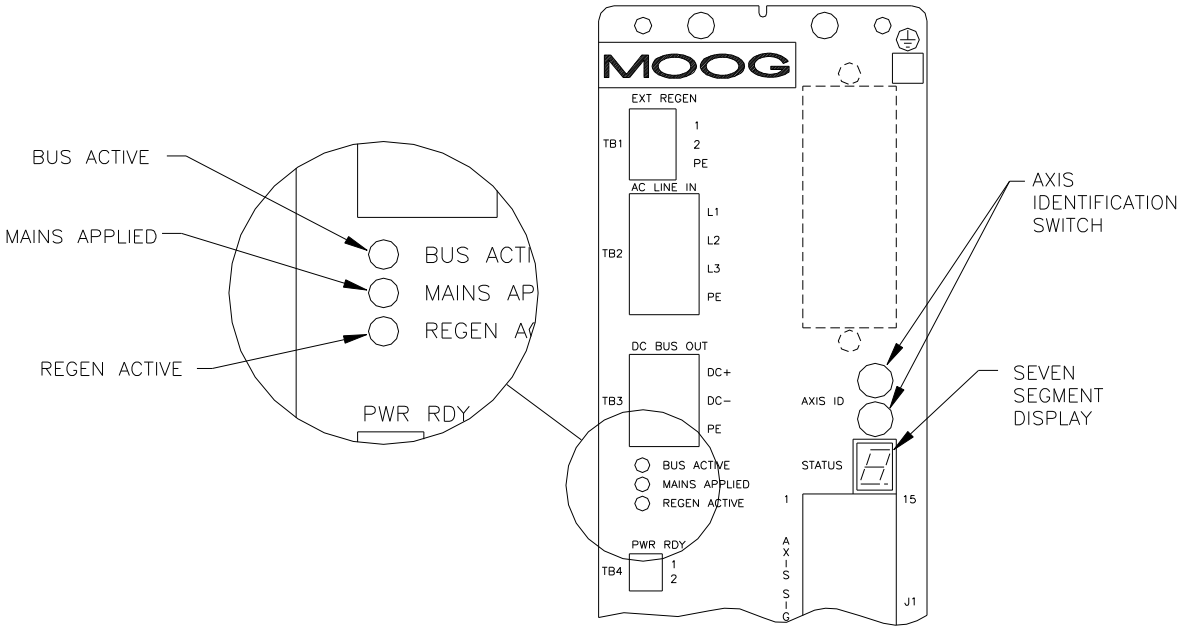

Figure 3.56:- T200-X10 (with PSU) LED's and 7-Segment Display

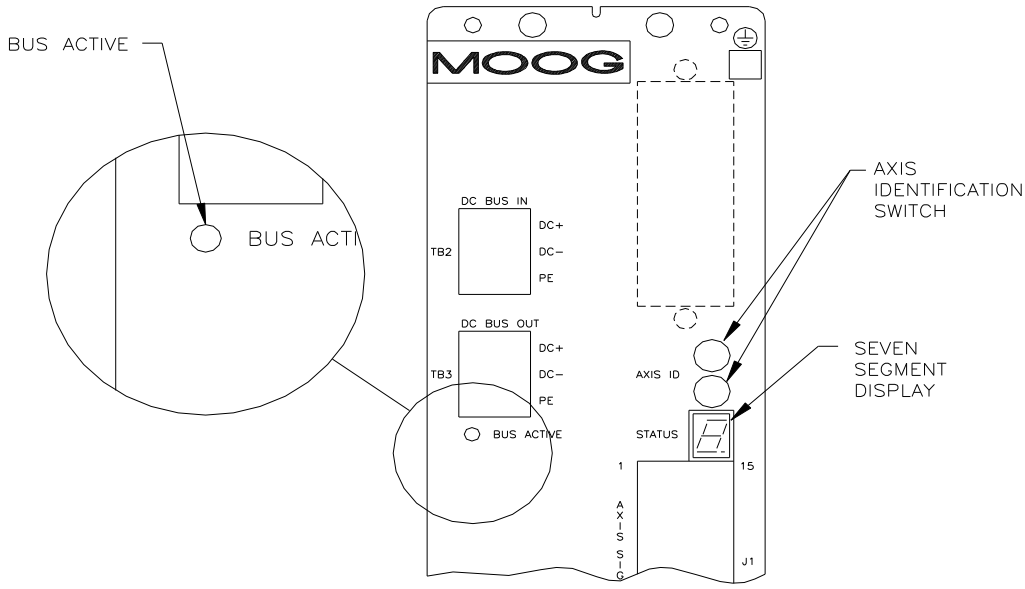

Figure 3.57:- T200-X00 (without PSU) LED's and 7-segment display

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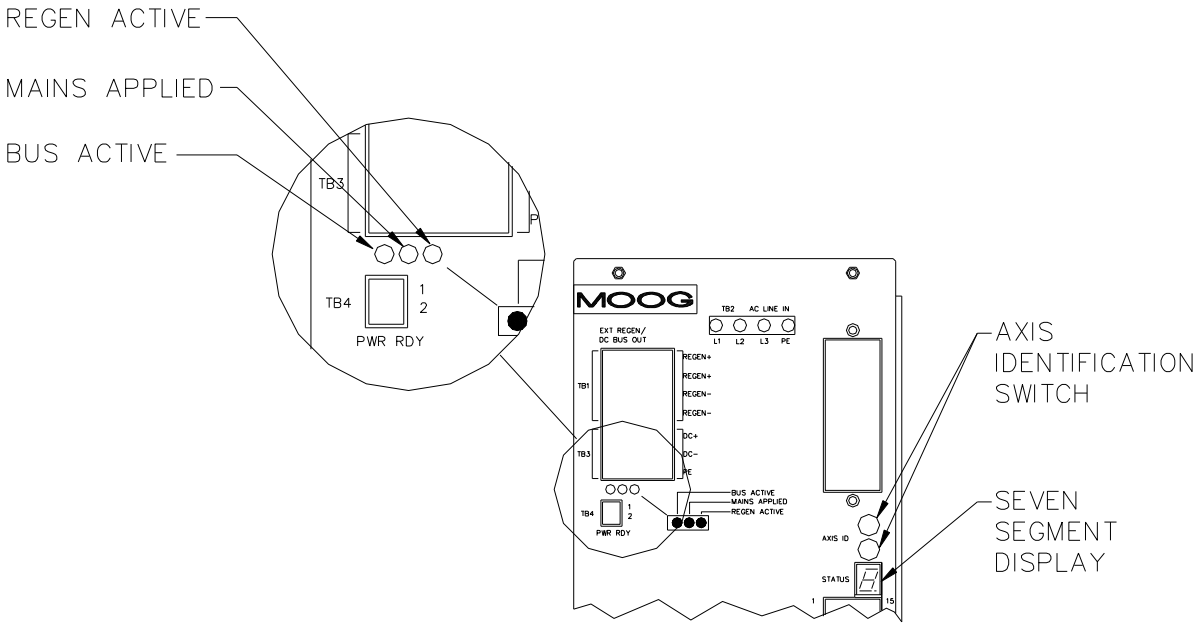

Figure 3.58:- T200-610/710 LED's and 7-Segment display

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SECTION 4: MOTOR GUIDE

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4.1 Motor Servo-Drive System

A Moog T200 Servo-Drive system consists of a T200 and a G4XX servo-motor. The selection of a particular motor and servo-drive for a specific application can be carried out with assistance of Moog selection sheets. These sheets are provided by local Moog sales offices. Moog-Size, a PC-Windows based program, is also available to aid in the selection process.

> The T200 can be configured to support Moog's D31X.. series and 30X.. series of servo-motors, for backward compatibility purposes. Consult Moog applications engineering for support of these particular motors with the T200.

4.2 Global Motor Models and Electrical Types

There are almost 1000 model number variations of G4XX motors. Most of these variations arise because of differences in the mechanical assembly of the motor. For example some motors have connectors rotated from the 'standard' configuration. These motors are then assigned a 'non-standard' model number. However from the point of view of the T200 servo-drive electronics, there is a much smaller number (about 45) of motors that have different electrical parameters (called non-standard or custom motors). The G4XX motor nameplate (see **Figure 4.1**) lists both the motor model and the motor's electrical type. The motor electrical type can also be used to configure the T200 with the appropriate motor parameters.

4.2.1 Motor Model Identification Scheme

All motor specific data in this User Manual is associated to flange size and stack length of the motors.

Custom/Non-Custom	The 3rd character determines if the motor is a standard or a non-standard (custom). If the 3rd character is a 0, then the motor is a non-standard (custom) model. (e.g. xx**0**x-xxx in the model number G402-123). Note that the "Stack-Length" field is then used for a different purpose than stack length indication:- it is then assigned sequentially to each of the custom motors.
Motor Size	Determined by the 4th character of the model number (e.g. Size G4x**2**-in the model number G42**2**-414).
Stack Length	Can be determined by means of the part number cross reference (see Table 4.1) by the 6th character of the model number (e.g. length =L10 per in the model number G422-**4**14).

Model Type	A model type designation (e.g. G2L10) is described by the following scheme:
	GxLyyz with:-
	x = motor size;
	yy = motor length;
	z = electric model (dropped for standard motors).

Brake	A description of an optional brake is added to the model type on the nameplate (for instance G2L10, **brake 0,9 Nm**).

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4.2.2 Motor Nameplate

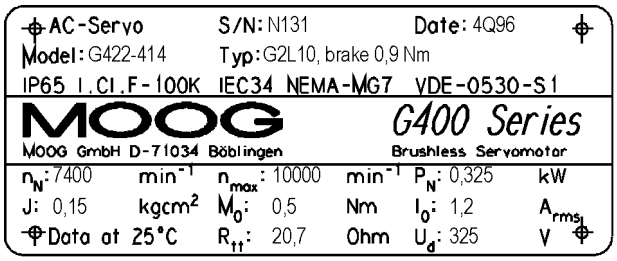
AC-Servo
S/N: N131
Date: 4Q96
Model: G422-414
Typ: G2L10, brake 0,9 Nm
IP65 I.Cl.F-100K IEC34 NEMA-MG7 VDE-0530-S1
MOOG
G400 Series
MOOG GmbH D-71034 Böblingen
Brushless Servomotor
nN: 7400 min-1 nmax: 10000 min-1 PN: 0,325 kW
J: 0,15 kgcm2 M0: 0,5 Nm I0: 1,2 Arms
Data at 25°C Rtt: 20,7 Ohm Ud: 325 V

Figure 4.1:- Example Nameplate

S/N:	serial number
Date:	production quarter and year
Model:	motor model number
Type:	electric model, description optional brake
n_N:	nominal speed (speed at P_N)
n_{max}:	maximum speed
P_N:	nominal power (maximum continuous power)
J:	moment of inertia
M_0:	continuous stall torque
I_0:	continuous stall current
R_{tt}:	terminal to terminal resistance
U_d:	bus voltage

Further electrical data can be found in the catalogue.

The nameplate serves to identify the product. Check whether the nameplate on the device matches the nameplate illustrated above. This documentation must not be used for commissioning and startup if the nameplates do not match. Devices without nameplate are not covered by the manufacturer's warranty and must not be put into operation.

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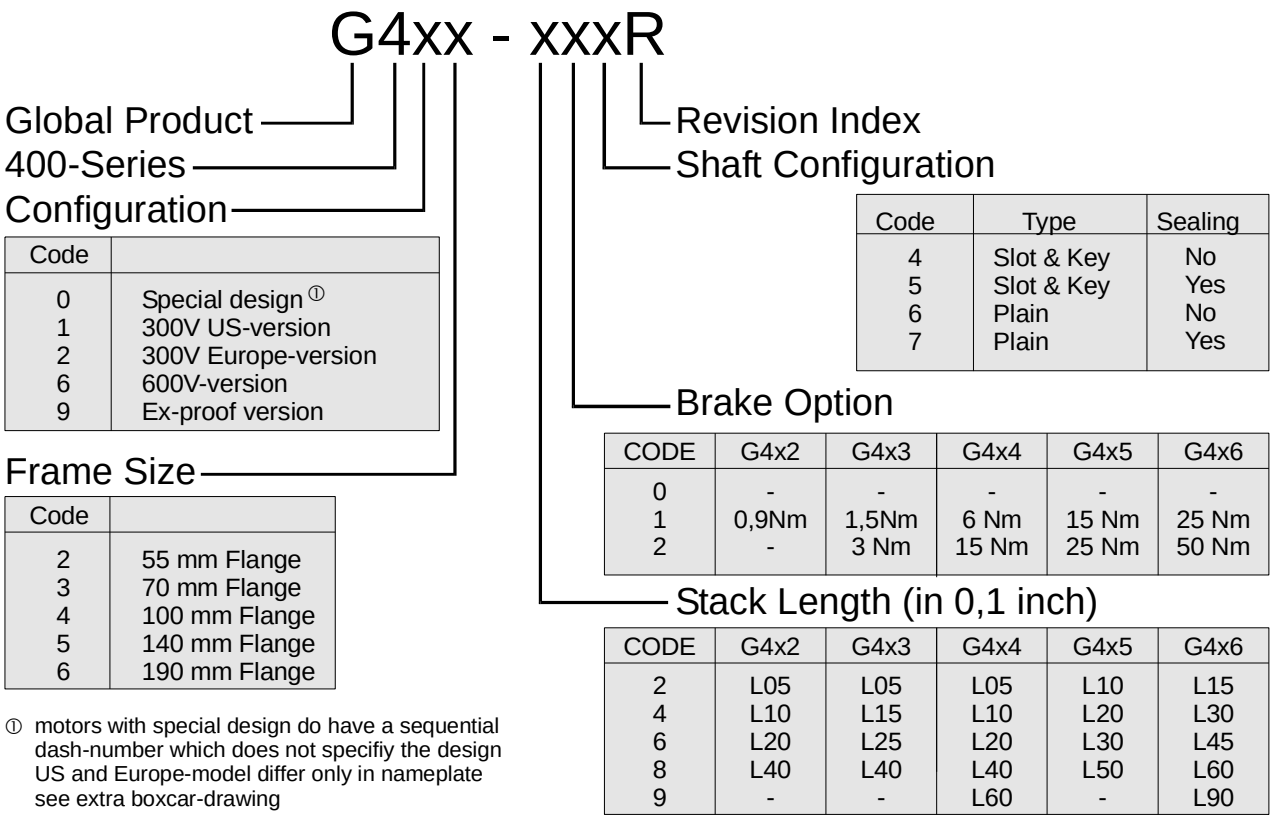
4.2.3 Motor Part Number Cross Reference

The order number for motors is made up as follows:



Code	
0	Special design ①
1	300V US-version
2	300V Europe-version
6	600V-version
9	Ex-proof version

Code	
2	55 mm Flange
3	70 mm Flange
4	100 mm Flange
5	140 mm Flange
6	190 mm Flange

Code	Type	Sealing
4	Slot & Key	No
5	Slot & Key	Yes
6	Plain	No
7	Plain	Yes

CODE	G4x2	G4x3	G4x4	G4x5	G4x6
0	-	-	-	-	-
1	0,9Nm	1,5Nm	6 Nm	15 Nm	25 Nm
2	-	3 Nm	15 Nm	25 Nm	50 Nm

CODE	G4x2	G4x3	G4x4	G4x5	G4x6
2	L05	L05	L05	L10	L15
4	L10	L15	L10	L20	L30
6	L20	L25	L20	L30	L45
8	L40	L40	L40	L50	L60
9	-	-	L60	-	L90

① motors with special design do have a sequential dash-number which does not specifiy the design US and Europe-model differ only in nameplate see extra boxcar-drawing

Table 4.1 :Motor Part Number Cross-Reference

Note that the T200 is not compatible with the 600V motor versions.

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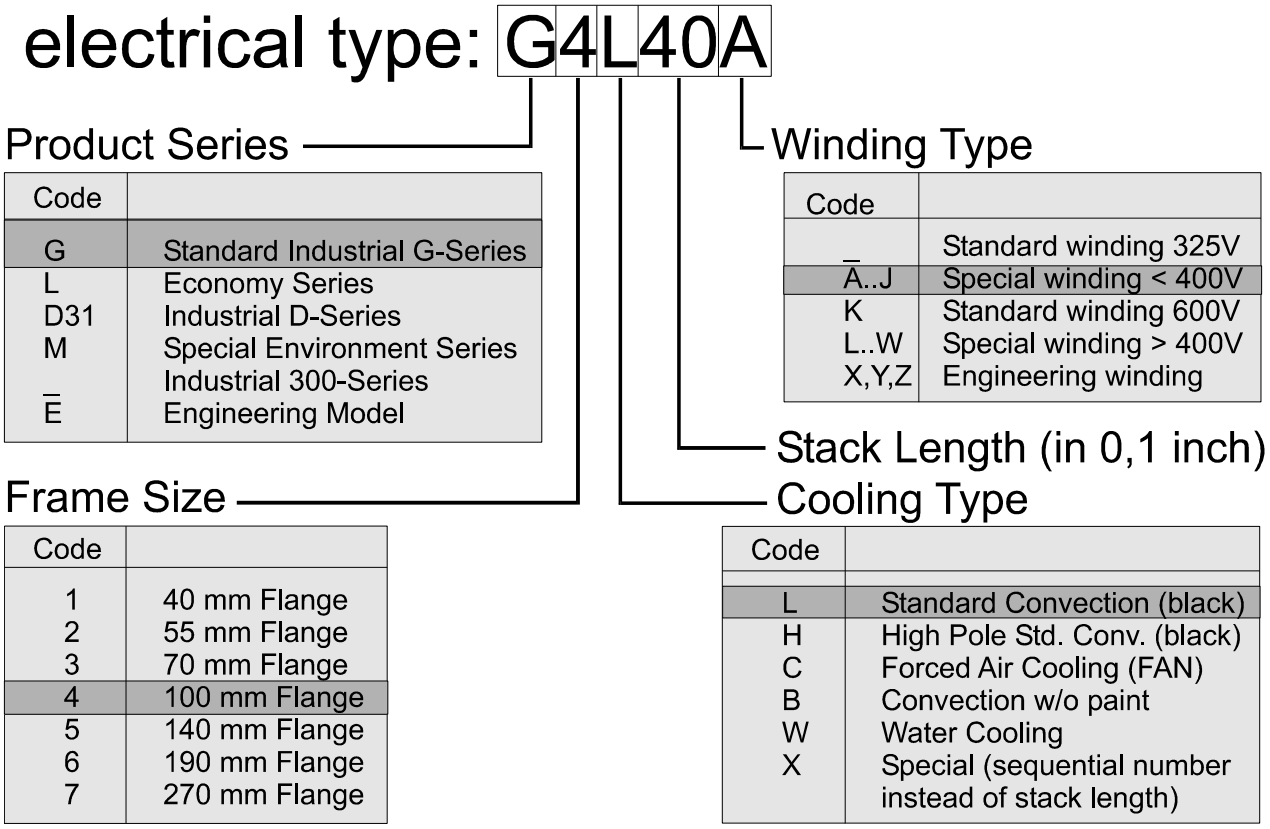
4.2.4 Motor Electrical Type Cross Reference



Code	
G	Standard Industrial G-Series
L	Economy Series
D31	Industrial D-Series
M	Special Environment Series
_	Industrial 300-Series
E	Engineering Model

Code	
_	Standard winding 325V
A..J	Special winding < 400V
K	Standard winding 600V
L..W	Special winding > 400V
X,Y,Z	Engineering winding

Code	
1	40 mm Flange
2	55 mm Flange
3	70 mm Flange
4	100 mm Flange
5	140 mm Flange
6	190 mm Flange
7	270 mm Flange

Code	
L	Standard Convection (black)
H	High Pole Std. Conv. (black)
C	Forced Air Cooling (FAN)
B	Convection w/o paint
W	Water Cooling
X	Special (sequential number instead of stack length)

Table 4.2 :Motor Electrical Type Cross-Reference

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4.3 Configuring the Motor in the T200 Servo-Drive

There are two ways of telling the T200 which type of motor is connected, listed in Sections 4.2.1 and 4.2.2 below.

4.3.1 Motor Configuration via WinDrive

WinDrive contains a database of the 'standard' motor models. The user can select either the motor's electrical-Type or the motor-Model as the search-key for the database. If the user has purchased a motor which has a 'non-standard' motor-Model, then the user can specify the electrical 'Type' (see Figure1 Motor Nameplate, for information on where to find this information on the motor) rather than the 'Model'. This selection is carried out via the Select-Motor dialog window's 'Motor Configured in Drive' field.

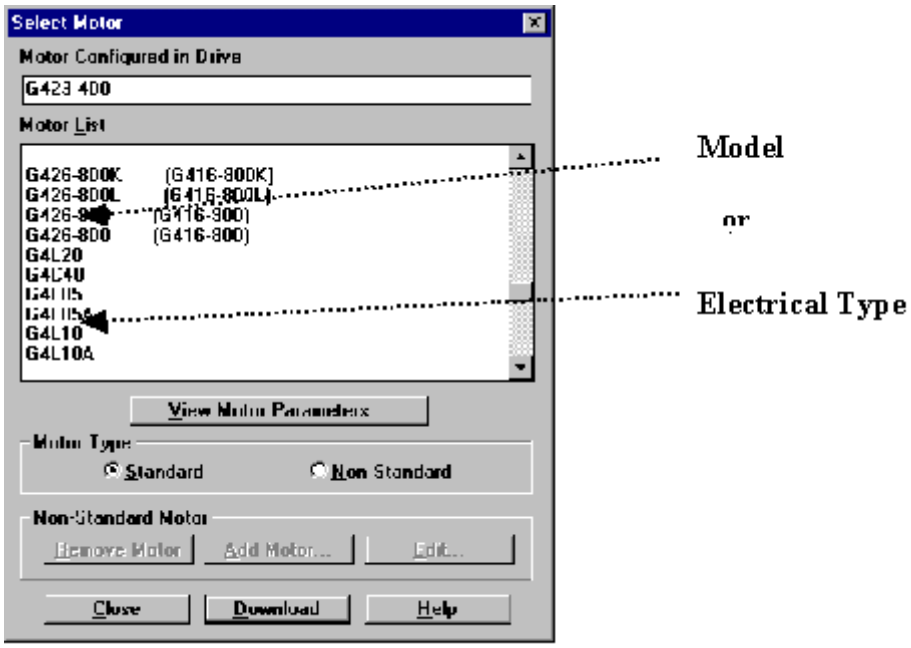

Figure 4.2:- Motor Selection via WinDrive User Interface

4.3.2 Motor Configuration via Hand Held Terminal

The '**SSM**' (Set Standard Motor) or the '**SNM**' (Set Non-Standard Motor) commands can be used to configure the T200 via the command line interface of the hand-held-terminal. Non-standard motors are not included in the hand-held-terminal's standard-motor list, though they may have a standard set of electrical parameters. Moreover the command line interface does not support the entry of the electrical Type. If the motor has a standard electrical Type, then the user can find the standard model which has the same electrical Type, and enter that standard model string using the **SSM** command.

Check the electrical **Type** on the motor nameplate. Then cross-reference in Table 4.2 below in order to determine the appropriate motor Model string to enter, using the **SSM** command.

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4.3.2.1 Example using SSM command

The motor nameplate shows a Motor Model of G404-123A (i.e. a non-standard motor model) and an electrical Type of G4L20. By checking for G4L20 in the left hand column of Table 4.2, the user finds that the equivalent standard motor is a G424-600. He uses the SSM command. He enters the string 'G424-600' and the T200 is configured automatically with the correct electrical parameter set.

Electrical Type	'Standard' Motor String to be entered via Command Line Interface		Electrical Type	'Standard' Motor String to be entered via Command Line Interface
G2L05	G422-200		G4L20	G424-600
G2L10	G402-400		G4L40	G424-800
G2L20	G422-600		G5L10	G425-200
G2L40	G422-800		G5L20	G425-400
G3L05	G423-200		G5L30	G425-600
G3L15	G423-400		G5L50	G425-800
G3L25	G423-600		G6L15	G426-200
G3L40	G423-800		G6L30	G426-400
G4L05	G424-200		G6L45	G426-600
G4L10	G424-400		G6L60	G426-800

Table 4.3 Electrical Type and Standard Model Equivalency Table

If the motor electrical type is not listed in the Table above, then the user should consult Moog Applications Engineering for support on motor entry.

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4.4 Motor-Drive Selection

Please consult your local Moog sales office or authorised distributor for selection of the appropriate T200 and motor for your application.

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4.5 Motor Performance Data

Temperature for Transport and Storage:	-25 °C to 90 °C
Operating Temperature:	-25 °C to 50 °C (higher temperature rating on demand)
Degree of Protection:	IP67 (DIN VDE 0470-1, EN 60529, IEC 529) (at shaft extension optional shaft seal is needed)
Installed Position:	Any (good heat dissipation permits higher continuous power)
Runout:	Class R (DIN 42955-R, IEC72)

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Motor type		Stall Data				Nominal Data				Miscellaneous Data						
		Continuous Stall Torque ①	Continuous Stall Current ①	Peak Stall Torque	Peak Stall Current	Rated Torque ②	Rated Current ②	Rated Power ②	Rated Speed ②	Theoret. No Load Speed ③	Maximum Permissible Speed ④	Torque Constant ⑤	Terminal to Terminal Resistance ⑥	Terminal to Terminal Inductance ⑥	Moment of Inertia w/o Brake	Weight w/o Brake
Model	Type	Mo [Nm]	Io [Arms]	Mmax [Nm]	Imax [Arms]	Mn [Nm]	In [Arms]	Pn [Watt]	Nn [rpm]	Ntheo [rpm]	Nmax [rpm]	kt [Nm/Arms]	Rtt [Ohm]	Ltt [mH]	J [kgcm²]	m [kg]
G4x2-2xx	G2L05	0.25	0.65	0.6	1.9	0.18	0.5	150	8100	10200	11500	0.37	50.90	29.7	0.09	1.0
G4x2-4xx	G2L10	0.5	1.2	1.45	3.7	0.42	1.0	325	7400	9000	10000	0.42	20.70	15.7	0.13	1.2
G4x2-6xx	G2L20	0.95	2.15	2.8	6.4	0.74	1.6	530	6800	7900	9000	0.46	9.90	9.1	0.22	1.5
G4x2-8xx	G2L40	1.8	2.85	5	8.3	1.26	2.1	820	6200	6300	7000	0.60	6.30	7.2	0.41	2.3
G4x3-2xx	G3L05	0.6	1.6	1.6	4.6	0.49	1.2	450	8800	9600	10500	0.40	15.20	18.8	0.16	1.4
G4x3-4xx	G3L15	1.7	3.2	4.9	10.6	1.44	2.7	950	6300	7200	8000	0.53	4.90	8.5	0.39	2.0
G4x3-6xx	G3L25	2.55	3.4	8.5	12.4	2.29	3.1	1150	4800	4900	5500	0.75	5.10	10.3	0.62	2.6
G4x3-8xx	G3L40	3.7	4.2	13	16.3	3.43	3.8	1400	3900	4100	4500	0.90	4.10	8.9	0.97	3.5
G4x4-2xx	G4L05	1.3	3.1	3.2	9.0	1.0	2.3	580	5800	8800	10000	0.42	5.10	8.52	1.05	3.0
G4x4-4xx	G4L10	2.6	4.8	6.5	15.0	1.7	3.1	950	5500	6900	8000	0.54	2.70	5.78	1.55	3.6
G4x4-6xx	G4L20	4.7	6.7	12.5	20.0	4.0	5.7	1800	4300	5200	5800	0.70	1.50	4.60	2.60	4.7
G4x4-8xx	G4L40	8.2	9.2	22	28.0	6.3	7.1	2310	3500	4200	4700	0.89	0.90	3.50	4.70	6.9
G4x4-9xx	G4L60	11	9.5	31	30	7.5	6.5	2400	3000	3300	3800	1.16	0.96	3.98	6.8	9.1
G4x5-2xx	G5L10	5.8	9.5	12.2	24	4.6	7.5	2310	4800	6100	6800	0.61	0.86	4.29	4.60	7.7
G4x5-4xx	G5L20	11.2	11	25.8	33	9.2	9.0	3370	3500	3800	4200	1.02	0.74	4.81	8.00	9.9
G4x5-6xx	G5L30	16.6	12.9	40	38	14.0	10.9	3960	2700	3000	3300	1.29	0.64	4.84	11.50	12.1
G4x5-8xx	G5L50	25	14.8	60	43	20.0	11.8	4610	2200	2200	2400	1.69	0.56	5.44	18.40	16.6
G4x6-2xx	G6L15	14	22	37	72	9.1	14.2	3810	4000	5700	6300	0.64	0.23	1.86	27.20	15.1
G4x6-4xx	G6L30	27	30	73	95	15.5	17.2	4870	3000	4200	4700	0.90	0.14	1.54	52.10	21.1
G4x6-6xx	G6L45	39	38	108	117	25.5	24.8	6680	2500	3500	3900	1.03	0.11	1.46	77.00	27.1
G4x6-8xx	G6L60	51	43	146	134	34.0	28.6	7830	2200	3000	3300	1.19	0.10	1.46	102.00	33.1
G4x6-9xx	G6L90	75	47	200	141	48	30	11000	2200	2400	3000	1.57	0.105	1.68	152	40

① Motor flanged onto a steel plate 300 x 300 x 12 mm with the maximum permissible overheating of the winding at 100 K over a still air environment (max. 40 °C)
② The nominal point is the point for maximum continuous power
③ Speed at which the EMF of the motor is equal to the d.c.-bus voltage
④ Speed at which the EMF of the motor reaches 360 V
⑤ $k_t = \frac{M_N}{I_N} = \frac{[Nm]}{[A_{RMS}]}$
⑥ Measured at 25 °C

conversions

1 Nm = 8.85 lb-in 1 kgcm² = 8.85×10^{-4} lb-in-sec² 1 kg = 2.2 lb 1 kW = 1.341 hp

Note: Shaded data is printed on the nameplate.

Table 4.4 Motor Performance Data

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4.6 Mounting and Installation

4.6.1 Motor Dimensions

	P_{max}	A					B	C	øAJ	øAK	AH	øU	BB_{max}	øBF	XD	R	S1xS2	D	BC	øE	F	G	H	M
	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm			Nm
	ISO 286								ISO 286	ISO 286	ISO 286	DIN 748, ISO 286	ISO 286	ISO 286	ISO 286 DIN 6885	ISO 286	ISO 286 DIN 6885		ISO 286			DIN 13-1	DIN 912 8.8	DIN 912 8.8
Model		**2xx**	**4xx**	**6xx**	**8xx**	**9xx**																		
G4x2-	55	109,4	122,4	147,4	198,4		17,0	9,0	63	40 $^{+0,011}_{+0,005}$	20	9 $^{+0,10}_{+0,01}$	2,5	5,5	14	7,2	3x3	3	0	24 $^{+0,52}_{-0}$	–	M2,5 x 8	M5 x 22	5
G4x3-	70	114,3	139,8	165,3	203,3		22,0	9,0	75	60 $^{+0,012}_{+0,007}$	23	11 $^{+0,025}_{+0,001}$	2,5	5,5	16	8,5	4x4	4	0	24 $^{+0,033}_{-0}$	–	M2,5 x 8	M5 x 22	5
G4x4-	100	133,2	146,2	171,2	222,2	273,2	21,1	9,8	115	95 $^{+0,013}_{-0,009}$	40	19 $^{+0,025}_{+0,002}$	3	9	32	15,5	6x6	4	0	35 $^{+0,06}_{-0}$	66,3	M4 x 16	M8 x 30	16
G4x5-	140	169,6	194,6	220,1	271,1		14,4	12,2	165	130 $^{+0,014}_{-0,011}$	50	24 $^{+0,025}_{+0,002}$	3,5	11	40	20	8x7	5	0	47 $^{+0,39}_{-0}$	98,8	M4 x 16	M10 x 40	30
G4x6-	190	186,5	224,5	262,5	301,0	377,0	37,0	11,0	215	180 $^{+0,014}_{-0,011}$	60	32 $^{+0,030}_{+0,002}$	4	13,5	40	27	10x8	10	0	50 $^{+0,039}_{-0}$	128	M4 x 16	M12 x 40	38

P_{max} Maximum width of motor (end view) excluding terminal housing etc.
A Motor length without shaft, pilot, mating connector
B Additional length of motor for motors with brake
C Thickness of flange plate of motor
øAJ Diameter of mounting bolt circle in flange of motor
øAK Diameter of pilot on flange of motor
AH Mounting surface of flange of motor to end of shaft
øU Diameter of shaft extension

BB_{max} Maximum height of pilot of mounting flange of motor
øBF Clearance hole in mounting flange of motor
XD Usable length of keyseat
R Bottom of keyseat to opposite side of shaft
S1 Width of key
S2 Height of key

D Distance between end of shaft and key
BC Distance between mounting flange of motor to shoulder on shaft (always =0 mm)
øE Diameter of hole for shaft in flange of motor
F Width of motor between recesses for mounting screws
G Thread in motor shaft (type and length)
H Recommended fixing screws (type and length)
M Tightening torque for flange screws

All dimensions without tolerance are according to DIN ISO 2768, part 1, category c

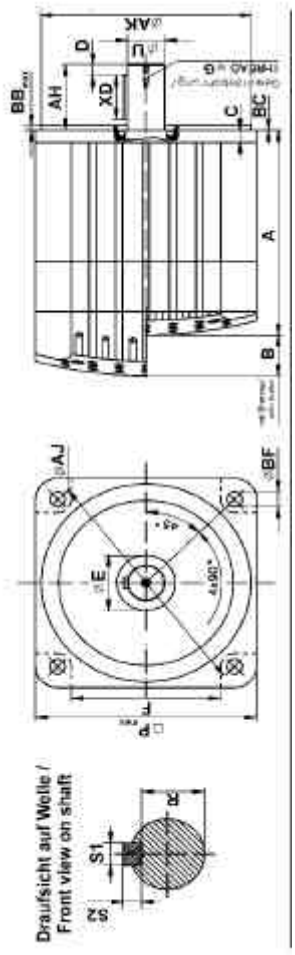

Table 4.5 Motor Dimensional Data

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Additional dimensions, e.g. for connectors and mating connectors can be found in the motor datasheet catalogues provided by Moog.

CAUTION - Do not hammer on, or press pulleys, gears, couplings, etc. onto the motor shaft. Internal damage will occur.

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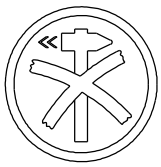
4.6.2 Motor Installation Guideline

MOOG recommends that hexagon socket head screws to DIN 912 8.8 (see column H in) be used to secure the motor. Assembly is made very much easier by using an Allen key with ball head, particularly in the cases of motor sizes 2 and 3. The screws used to install these motor sizes must not be more than 40 mm long.

MOOG motors can become very hot (up to 155°C winding temperature) in operation. Good heat dissipation must therefore be ensured when installing the motor, i.e. it should be flanged onto a suitably solid metal part of the machine. Adequate convection must also be ensured. In individual cases, the motor must furthermore be protected against contact due to the risk of burns. Forced cooling (e.g. with fans) will increase the continuous power, while bad convection may decrease the continuous performance.

Before connecting a coupling to the motor shaft, the shaft must be thoroughly degreased. When using a degreasing agent, care must be taken to prevent it entering the bearing. Otherwise the bearings permanent lubrication can no longer be guaranteed. Moog recommends the use of a clamp coupling or shrink connection to ensure reliable torque transmission. An inexpensive and service friendly connection is possible with the slot and key option (ensure tight slot tolerances).

Impermissibly high axial and radial forces on the shaft can result in motor damage during installation. The service life of the motor is impaired if the bearing is damaged in any way. Adjusting the rotor shaft by force can impair the correct functioning of the optional brake to such an extent that it has little or no braking effect. Excessive pressure and impacts on the front end of the shaft and rear housing cover must therefore be avoided under all circumstances.



Delicate part (sticker on servomotor). A hammer must not be used to force the gearing or gearwheel onto the shaft when installing such parts. The screw thread in the center of the shaft must be used for this purpose. An extractor supported on the center of the shaft must be used when dismantling the parts. The permissible axial and radial forces **are in all cases exceeded** by the impulses due to hammering.

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4.6.3 Rated Bearing Load Capacity

Radial load capacity, shown in Figure 4.3 to Figure 4.7, are for a B10 life of 20,000 hours. The load is applied at shaft extension midpoint. Curves are based on minor axial shaft loads. Consult factory for other loading conditions. Maximum permissible axial and radial forces for brushless MOOG servomotors during installation refer to Table 4.7.

Motor size	**G4x2**	**G4x3**	**G4x4**	**G4x5**	**G4x6**
Axial force 1)	150N	150N	300N	400N	500N
Radial force 1)	500N	500N	1000N	1600N	2000N
1): During installation. Lower loads apply for the rotating motor, see catalog.					

Table 4.6 Installation Loads

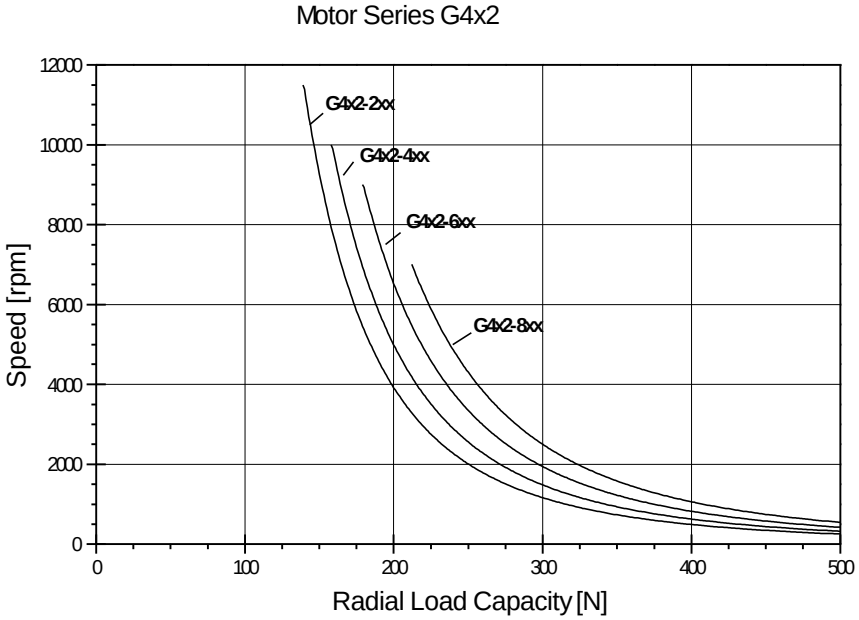

Figure 4.3:- Radial Load Capacity G4x2

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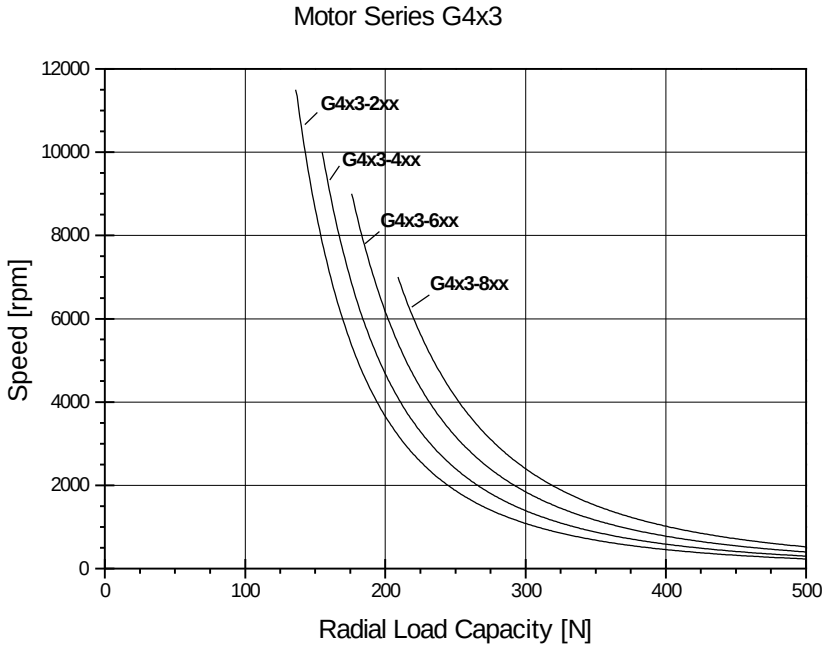

Figure 4.4:- Radial Load Capacity G4x3

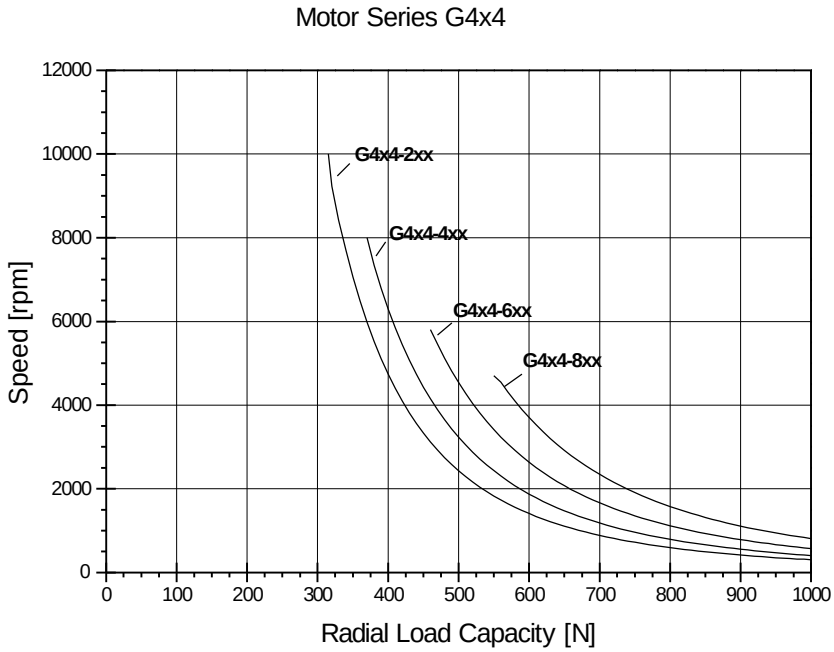

Figure 4.5:- Radial Load Capacity G4x4

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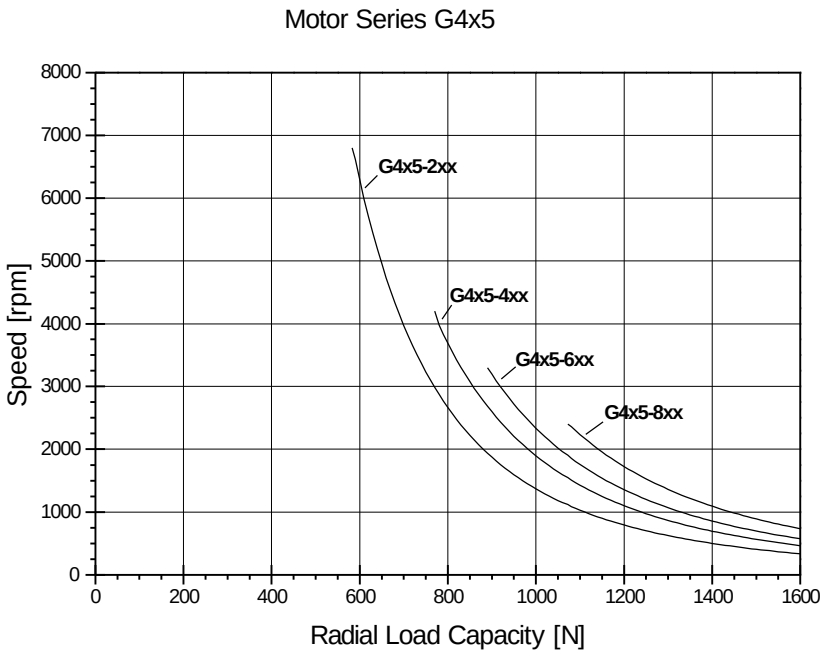

Figure 4.6:- Radial Load Capacity G4x5

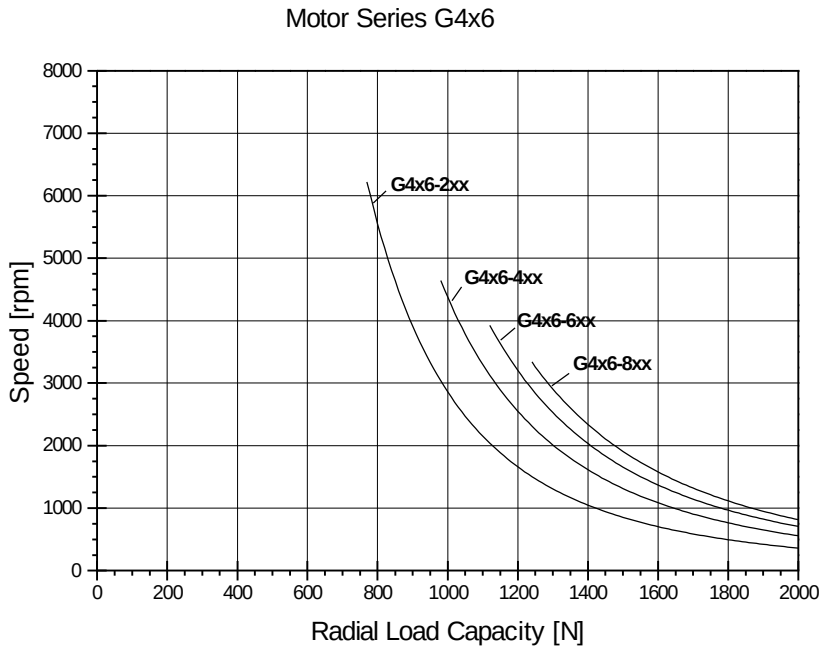

Figure 4.7:- Radial Load Capacity G4x6

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4.6.4 Coupling

A flexible coupling offers the advantages of economy, allowance for misalignment, and reduction of backlash. Flexible disc or bellows style couplings are recommended. The couplings are available for both plain shaft as well as for slot and key configurations. The shaft key should then be a close clearance or light press fit into the coupling key-way. Refer to Figure 4.8:- Motor Load Coupling , for flexible coupling detail.

CAUTION:- A rigid coupling should not be used. Normal runouts and eccentricities will result in damage to motor and/or load shaft and bearings.

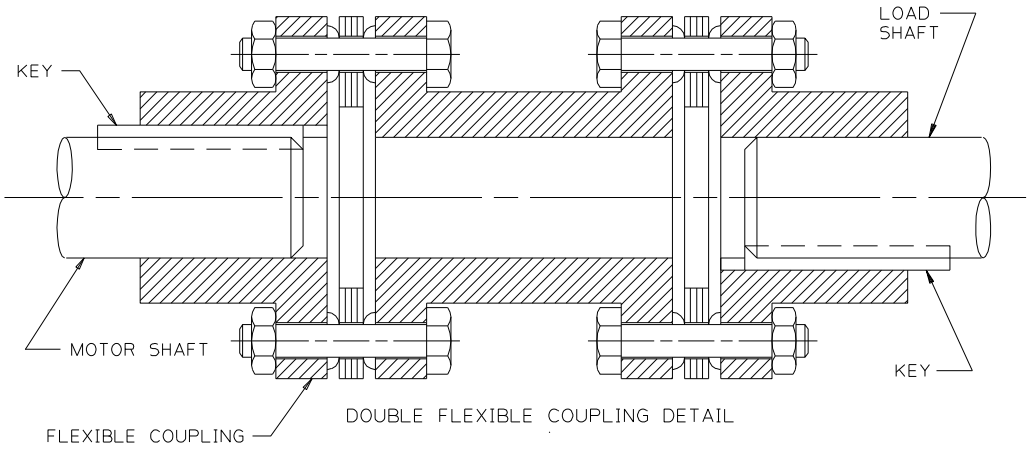

Figure 4.8:- Motor Load Coupling

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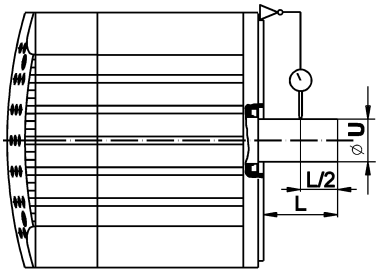
4.6.5 Runout

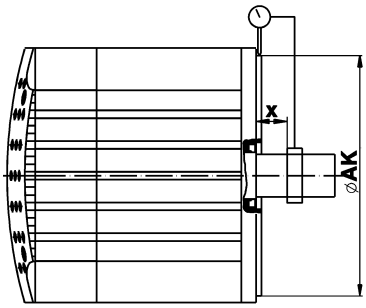
The reduced runout provided by MOOG motors allows the attachment of various gear heads. The precision manufacturing of the motor avoids loads caused by misalignments between motor and gear heads.

Diameter of the Shaft Extension øU [mm]	Maximum Runout Tolerance Class R [mm]
to 10	0.015
over 10 to 18	0.018
over 18 to 30	0.021
over 30 to 50	0.025
L=AH see Table 4.6	

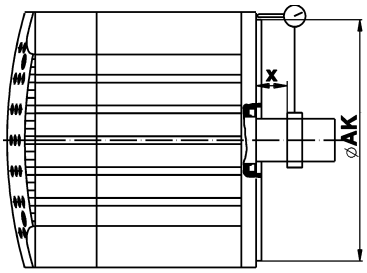


Rundlauf / runout

Table 4.7 Shaft Runout



Koaxialität / concentricity



Planlauf / perpendicularity

Pilot Diameter of Mounting Flange øAK [mm]	Maximum Concentricity and Perpendicularity Tolerance Class R [mm]
to 22	0.025
over 22 to <40	0.03
40 to 100	0.04
over 100 to 230	0.05
over 230 to 450	0.063
for øAK values)	

Table 4.8 Flange Concentricity/Perpendicularity

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4.6.6 Design Standards

The G400 series has been designed, assembled and tested in conformity with the following standards. (see Table 4.9 Motor Design Standards and Table 4.11 for design standards)

Standard	**International**	**Europe**	**Germany**	**USA**
English	**IEC** **I**nternational **E**lectrotechnical **C**ommission	**EN CENELEC** Europäisches Komitee für **E**lektrotechnische **N**ormung	**DIN / VDE** **D**eutsche **I**ndustrie **N**orm / **V**erband **D**eutscher **E**lektrotechniker	**NEMA / NEC** **N**ational **E**lectric **C**ode MG.-...
Certified company	ISO 9001	EN ISO 9001	DIN ISO 9001	ISO 9001
Quality systems - model for quality assurance in design / development, production, installation and servicing	ISO 9001	EN ISO 9001	DIN ISO 9001	ISO 9001
Machine guidelines (CE Machine safety directive)	89/392/EWG, 91/368/EWG, 93/44/EWG	89/392/EWG, 91/368/EWG, 93/44/EWG	89/392/EWG, 91/368/EWG, 93/44/EWG	
EMC guidelines (CE-EMC directive)	89/336/EWG, 93/68/EWG, 93/44/EWG	89/336/EWG, 93/68/EWG, 93/44/EWG	89/336/EWG, 93/68/EWG, 93/44/EWG	
Low voltage guidelines (CE - Low voltage directive)	73/23/EWG, 93/68/EWG, 93/44/EWG	73/23/EWG, 93/68/EWG, 93/44/EWG	73/23/EWG, 93/68/EWG, 93/44/EWG	
Standard for safety of electric motors				UL 1004 (1994)
Safety of machinery, electrical equipment of machines, part 1: general requirements	IEC 204-1	EN 60204-1	DIN EN 60204-1 VDE 0113-1	

Table 4.9 Motor Design Standards

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Relevant standards for electrical equipment

Standard	International	Europe	Deutschland	USA
English	**IEC** **I**nternational **E**lectrotechnical **C**ommission	**EN CENELEC** Europäisches Komitee für **E**lektrotechn. **N**ormung	**DIN / VDE** **D**eutsche **I**ndustrie **N**orm / **V**erband **D**eutscher **E**lektrotechniker	**NEMA / NEC** **N**ational **E**lectric **C**ode MG.-...
Rotating electrical machines, Rating and performance	IEC 34-1 IEC 2/915/CDV: 1995	EN 60034-1	DIN EN 60034-1 VDE 0530-1	MG 1-1.65
Rotating electrical machines, Methods for determing losses and efficiency and performance	IEC 2G/73/FDIS	EN 60034-2	DIN EN 60034-2 VDE 0530-2	
Rotating electrical machines, Classification of degrees of protection provided by enclosure	IEC 34-5	EN 60034-5	DIN EN 60034-5 VDE 0530-5	MG 1-1.25 MG 1-1.26
Rotating electrical machines, Methods of cooling“(IC-Code)	IEC 34-6	EN 60034-6	DIN EN 60034-6 VDE 0530-6	MG 1-1.25 MG 1-1.26
Rotating electrical machines, Classification of types of construction and mounting arrangements (IM Code)	IEC 34-7	EN 60034-7	DIN EN 60034-7 VDE 0530-7	MG 1-4.03
Rotating electrical machines, Terminal markings and directions of rotation	IEC 34-8	EN 60034-8	DIN EN 60034-8 VDE 0530-8	MG 1-2.61
Rotating electrical machines, Noise limits	IEC 34-9	EN 60034-9	DIN EN 60034-9 VDE 0530-9	N/A.
Insulation coordination for equipment with low-voltage systems. Part 1 Principles, requirements and tests	IEC 664-1		VDE 0110-1	
Insulation coordinates for equipment with low-voltage systems. Part 2 Partial discharge tests, application guide	IEC 664-2		VDE 0110-2	
Connectors and plug-and-socket-devices, for rated voltages up to 1000V a/c., up to 1200 V d/c. and rated currents up to 500 A for each pole			DIN VDE 0627	

Table 4.10 Electrical Design Standards

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Relevant standards for mechanical design

Standard	International	Europe	Deutschland	USA
English	**IEC** **I**nternational **E**lectrotechnical **C**ommission	**EN CENELEC** Europäisches Komitee für **E**lektrotechn.**N**o rmung	**DIN / VDE** **D**eutsche **I**ndustrie **N**orm / **V**erband **D**eutscher **E**lektrotechniker	**NEMA / NEC** **N**ational **E**lectric **C**ode MG.-...
Degrees of protection provided by enclosure (IP code)	IEC 529	EN 60529	DIN EN 60529 VDE 0470-1	
Cylindrical shaft ends for electrical machines	IEC 72 ISO/R 775-1969		DIN 748-1 & 3	MG-11...
Mounting flanges for rotating electrical machinery			DIN 42948	
Dimensions, tolerances and mounting				NEMA MG-7
Tolerances of shaft extension run-out and of mounting flanges for rotating electrical machinery	IEC 72		DIN 42 955	
Mechanical vibration, balance quality requirements of rigid rotors, determination of permissible residual unbalance	ISO 1940-1		DIN ISO 1940-1	
Mechanical vibration, balance quality requirements of rigid rotors, Balance errors	ISO 1940-2		DIN ISO 1940-2	
Ball bearings, conrad type, for electrical machines, tolerances and radial clearance			DIN 42966	
Drive type fastenings without taper action, parallel keys, keyways, deep pattern			DIN 6885-1	
ISO general purpose metric screw threads. Part 1 coarse pitch threads in diameter range 1 mm to 68 mm, nominal sizes	ISO 724		DIN 13-1	
General tolerances, tolerances for linear and angular dimensions without individual tolerance indications	ISO 2768-1	EN 22768	DIN ISO 2768-1	

Table 4.11 Mechanical Design Standards

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4.6.7 Motor Brake Data

The following are the specification data for the G4XX motor brakes. Options are specified via the box-car drawing.

Parameter	G4X2 Series Brakes	G4X3 Series Brakes		G4X4 Series Brakes		G4X5 Series Brakes		G4X6 Series Brakes	
	Option 1	Option 1	Option 2	Option 1	Option 2	Option 1	Option 2	Option 1	Option 2
Rated Braking Holding Torque [Nm]	0.9	1.5	3.0	6.0	15.0	15.0	25.0	25.0	50.0
Inertia [kg cm^2]	0.02	0.07	0.18	0.54	1	1	3.6	3.6	15.1
Rated Voltage [V]	24V±15%	24V±15%	24V±15%	24V±15%	24V±15%	24V±15%	24V±15%	24V±15%	24V±15%
Time to Disengage, t_1 [ms]	20	20	20	30	50	50	80	80	120
Time to Engage, t_2 [ms]	15	15	15	25	35	35	40	40	45
Current at 24V to release [A]	0.46	0.46	0.42	0.54	0.79	0.79	1.0	1.0	1.25

Table 4.12 G4XX Motor Brake Data

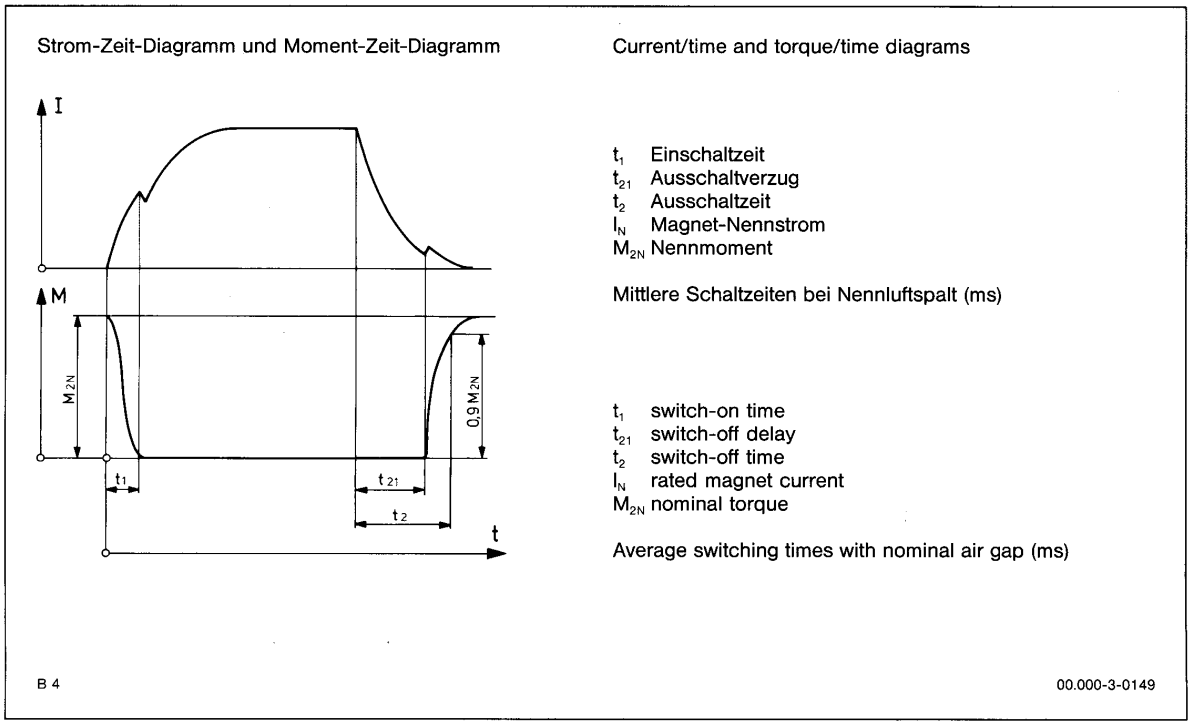

Figure 4.9:- Current/time and torque/time diagrams

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SECTION 5: QUICK-START

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5.1 Getting Started

The following section describes a "Quick Start" method for the Moog T200 Servo-drive. This will allow the user to quickly and easily set up a T200 motor-drive system and start basic motor operations. The user should first read and be familiar with sections 1, 2 and 3 of this manual before attempting to follow this quick start procedure. This is especially true with respect to the safety notices and other hazard warnings.

5.1.1 Initial Preparation

Install the drive and wire the system as per Section 3. As a minimum, the a.c. mains input cable, the 24Vd.c. or 120Va.c. input cable, the Motor cable, the Resolver cable and the Axis I/O cables must be pre-wired. One of the drive communication methods (e.g. PC based WinDrive, hand-held terminal etc.) must also be implemented.

NOTE: This quick start procedure assumes a first time power up on a previously non-configured drive.

5.1.2 Power Up Sequence

Apply 24Vd.c. or 120Va.c. logic power to the T200. The T200 control section will begin its start up cycle. The T200 now needs to be initialised with valid start-up data so that the control card can complete this start up cycle. The T200 Servo-drive needs a valid motor to be configured to allow the control card to start.

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5.1.3 Starting the Drive

The MS-Windows-based Windrive interface may be used to quickly configure the T200, and check basic wiring and installation as well as simple backward and forward motion of the connected load.

5.1.3.0 Preliminary Step:- Activate WinDrive

Install Windrive using the install instructions detailed in the WinDrive Software Kit, or as described in Section 7.2. Note that the PC should be connected to the T200 using the RS232 serial cable described in Section 7.4.1.

Under the Drive Menu item, select the Basic Drive Setup option. This will lead the user through the following set of steps, to perform a quick-setup on the T200.

5.1.3.1 *Step 1*:- Selection of the Motor

The first user choice concerns the selection of the motor. The user may select between standard and non-standard motor types (non-standard if the motor Model has a **0** at the 3rd character e.g. G4**0**3-123). The motor is then selected by choice of the motor **Model** or **Electrical Type** from the scrollable Motor List. The user should first check the Motor Nameplate for the Electrical Type. The appropriate Electrical Type should then be selected from the Motor List. If the user cannot find or see the Electrical Type on the Nameplate, then the motor Model should be checked (e.g. G423-400A).

Once the appropriate motor is selected, then the user should left-click on the Download button to configure the T200 with the motor data set. Refer to Section 4.1 and Section 4.2 for a more detailed explanation of how the motor is configured. Exit from this dialog to setup the Reference Source.

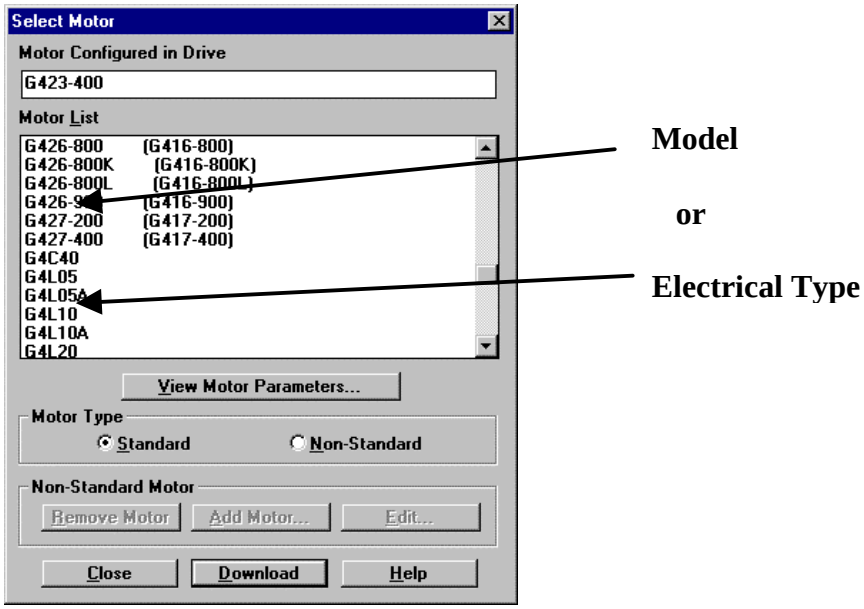

Figure 5.1:- Selecting the Motor

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5.1.3.2 *Step* 2:- Setup the Reference Source

The user should next select the reference source for the T200. The Reference Source determines where the reference signal is coming from.

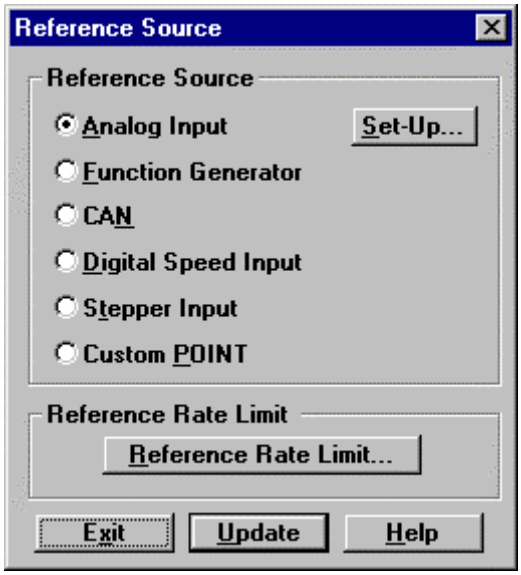

Figure 5.2:- Selecting the Reference Source

The appropriate choice should first be made by selection of the appropriate Radio Button. The Set-Up button should then be left clicked to setup details of the particular reference mode, in order to ensure that the T200 is operating correctly.

Moog recommends that the T200 unit is operated in Function Generator Mode, with very low excitation values (Speed Amplitude 100RPM, Speed Offset 0RPM, Torque Amplitude 0.5Nm, Torque Offset 0Nm, Period 1s), in order to check that the unit is wired correctly. (When the Quick-Start sequence is completed, then the unit can be enabled and the movement checked, to do a simple check that the T200 is wired correctly.)

Please refer to Section 6 for a more detailed explanation of the operation of the T200 in various reference modes.

Click the update button to activate the settinge. Click Exit to leave the dialog box.

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5.1.3.3 *Step* 3:- Setup of the Torque and Velocity Limits

The T200 AUTO_MAN digital input sets the T200 into either the Automatic or the Manual mode of operation. The Automatic mode corresponds to normal machine operation, at typical machine velocity and torque levels. The Manual mode is provided to ensure that via a digital input, the T200 can be switched to lower levels of torque and velocity, to ensure machine and personnel safety. The user should program the appropriate limits of torque and velocity for each mode.

The user is now prompted to enter the appropriate velocity and torque limits for the motor. At this stage of the setup, it is NOT recommended that the user disables the manual mode:- so that the Manual Mode Disable button should NOT be ticked. The user should ensure that the Normal and Manual Velocity and Torque Limits are set to values which ensures the safe operation of the machine.

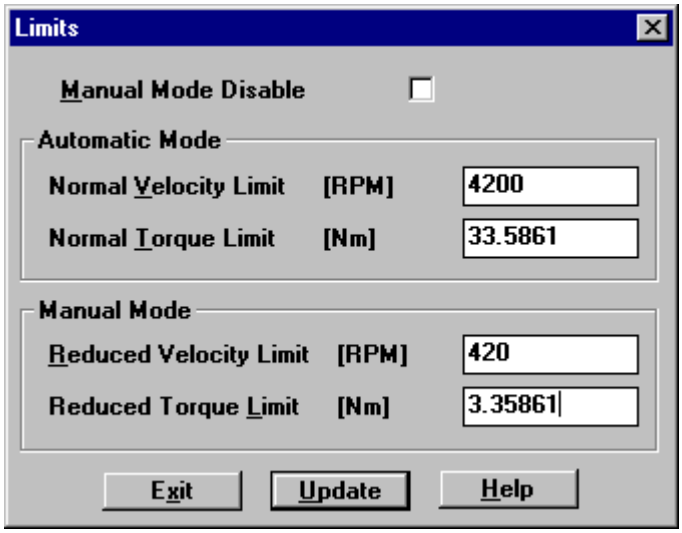

Figure 5.3:- Selecting the Velocity and Torque Limits

Once the values are set, click the Update Button. Click Exit to leave the dialog box.

5.1.3.4 *Step* 4:- Setting Limit Switch Parameters

If hardware limit switches are used on the user's applications, then he should connect these using the appropriate digital inputs as detailed in Section 3.15. The user may also disable the limit switches via a software command, by ticking the Limit-Switches-Disabled box. The Quick-Stop Deceleration rate is set by default to 10000 rad/s^2. This default value should prevent damage to mechanical elements connected to the load. The user should program this to a value that ensures a high deceleration rate but no damage to mechanical elements connected to the load, upon such a limit switch activated safety-stop.

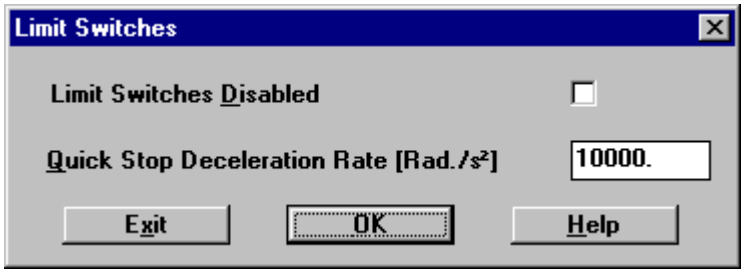

Figure 5.4:- Setting Up the Limit Switches

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5.1.3.5 *Step* 5:- Basic Tuning

The next step is to set the control mode. In order to check that the drive is wired correctly, Moog recommends that the drive is placed in Velocity Mode with a function generator reference (Step 2) to cause slow backward and forward movement. (Note however that if the axis is connected to a vertically mounted load or has a offset load torque, then this option should not be used.).

In order to place the drive in Velocity Mode, left click on the Velocity button in the Mode menu. Note that the T200 default values for Velocity Loop Gain and Integral Time Constant should be sufficient to turn the motor.

Note that tuning is described in detail in Section 6.6.

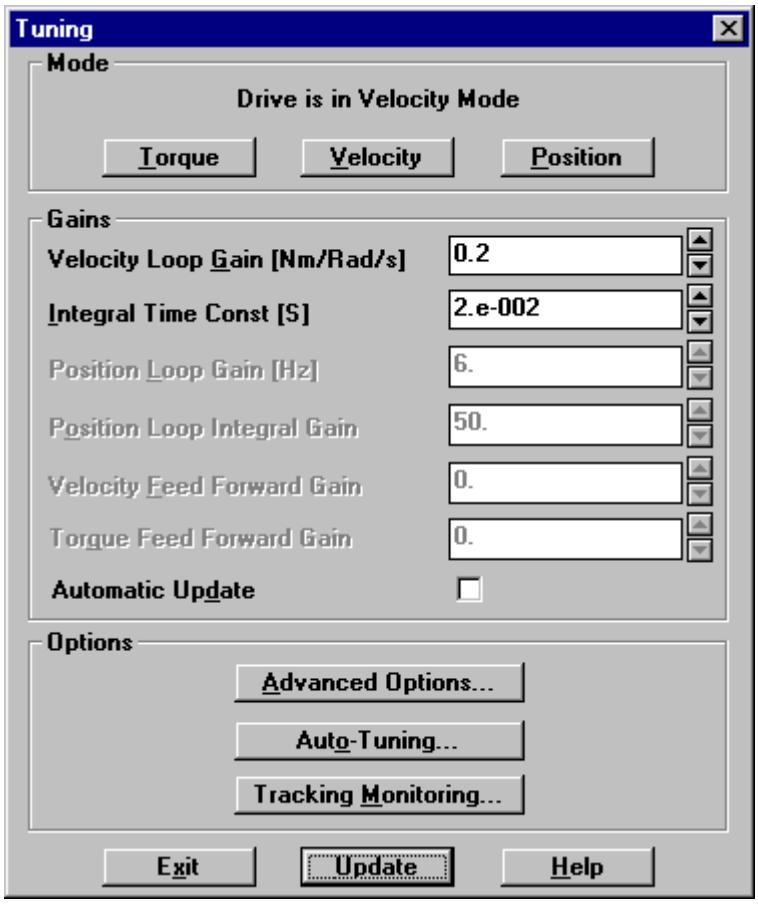

Figure 5.5:- Setting Up the Control Mode and Tuning Parameters

Click the Update Button to activate the settings. Click Exit to leave the dialog box.

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5.1.3.6 *Step 6:-* Encoder Simulation

Many applications, especially those applications that use the T200 in ±10V command Velocity or Torque Mode, use the T200's inbuilt Encoder Simulation to feed back the motor shaft position to a master Motion Controller System. The user should set the number of Lines per Revolution to match that required by the Motion Controller by setting the Number of Lines per Revolution input. Moog recommends the use of the 1024 or 512 lines per revolution options.

The Encoder Simulation is described in detail in Section 6.9.

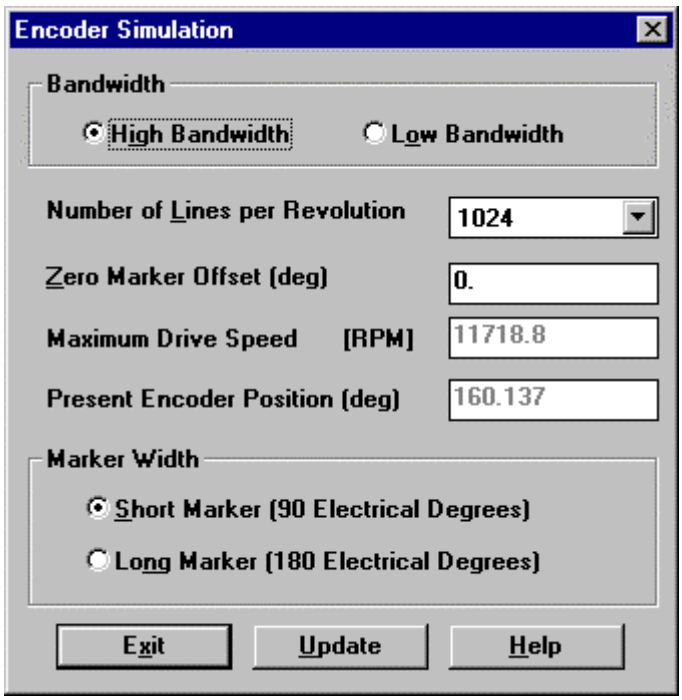

Figure 5.6:- Setting Up the Encoder Simulation

Click the Update Button to activate the settings. Click Exit to leave the dialog box.

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5.1.3.7 *Step 7:-* Regen Resistor Configuration

If an external regen resistor is used in the user's configuration the proper regen resistor need to be selected. This is necessary to ensure proper functionality of the regen exceeded feature which indicates that the cont. regen power of the selected regen resistor is exceeded.

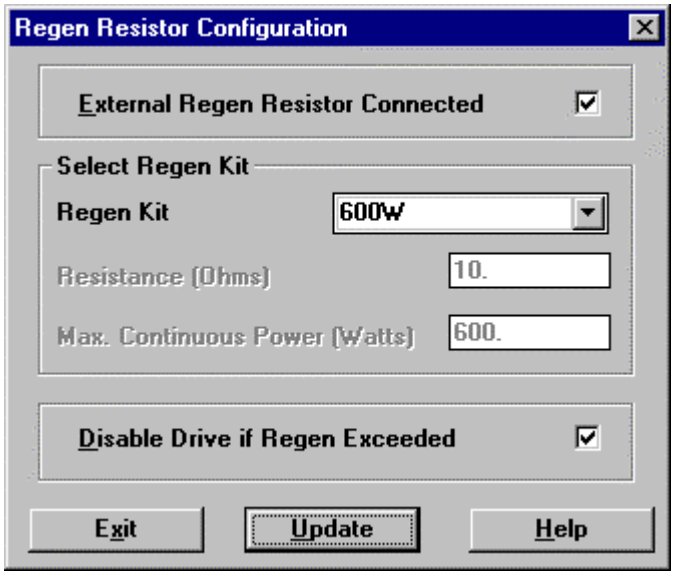

Figure 5.7:- Regen Resistor Configuration

Click the Update button to activate the settings. Click Exit to leave the dialog box.

5.1.3.8 *Step* 8:- Saving the Settings

The user's parameter settings should now be saved to the T200's non-volatile memory, such that when power is removed, and restored, the T200 will initialise itself with these parameters. To save the parameters to non-volatile memory, the user should left-click on the Save button. A pop-up information will then alert him that the parameters have been saved to EEPROM successfully.

Figure 5.8:- Setting Up the EEPROM

Exit from this dialog to energise the T200 and check basic movement of the load.

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5.1.3.9 *Step 9:-* Enabling the T200 and Causing Movement of the Motor

Apply 230Vac mains power to the mains inputs of the T200. Wait 5s for completion of softstart. After this time the T200 should close the Power Ready Relay to indicate a successful soft start-up. Note that this relay should be used in an interlock fashion to signal to all connected T200s that they can be enabled. Enabling in this case means that power is applied to the output inverter bridge and means that the motor can be activated.

If the Power Ready output indicates that no fault exists on a T200 with integral PSU then the T200 and all connected T200 without integral PSU may be enabled (i.e. high power applied to the motor windings).

The T200 may be enabled using the hardware ENABLE digital input of J1, which must be set active to allow the application of high power to the motor. When the hardware enable is active, the T200 may be enabled and disabled under software control using the F3 key when WinDrive is active. Note however that no T200 should be enabled before the Power Ready relay has closed, including the T200 that contains the integral PSU.

If the user followed the recommended setup (Velocity mode, Function Generator reference), then the T200 may now be enabled and the motion of the connected load checked. Note that Section 10 contains recommendations for troubleshooting.

Figure 5.9:- Enable/Disable/Quick-Stop Floating Toolbar.

WARNING - Ensure that all listed safety precautions are observed when performing this tuning operation. Ensure that the motor is securely mounted on a suitable fixture. Sudden and considerable movement of the motor, with a risk of serious injury, will occur during high speed reversals if the motor is not securely mounted.

When finished, close down WinDrive by left clicking on the File-Exit menu item, or by selection of other standard Windows program exit mechanisms.

5.1.4 Power-Down Sequence

Disable the Power Amplifier (i.e. remove power to the motor windings). Save the parameters to non-volatile storage using 'Save to EEPROM' in the 'File' – Menu.

Remove 230Va.c. mains. Wait at least 5minutes for the fast bus discharge. Note that in abnormal circumstances, if damage has occurred to the T200 then it will take at least 5 minutes for the internal high voltage to discharge.

Remove 24Vd.c. or 120 Va.c. logic backup power from the T200

The sequences described above are those recommended for normal power up/down events. There will be circumstances where these sequences cannot be maintained (e.g. mains power failure). The T200 is designed to survive simultaneous mains and 24Vd.c. or 120 Va.c. logic backup power removal.

The above short sequence gives the user a step by step procedure on how to install, set-up, and operate the Moog T200 integrated servo-drive in its most basic format. The T200 drive system has many advanced features necessary for typical servo applications that are not covered here.

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SECTION 6: T200 FUNCTIONAL OVERVIEW

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6.1 Introduction

This section describes the functionality of the T200. It details the various modes of operation and the I/O that operate with these modes. The WinDrive Graphical User Interface or the Hand Held terminal can be used to configure and tune a T200 and diagnose problems in a T200 application.

This section will provide an overview of functionality. Section 7 provides an overview of the T200's WinDrive user interface, which provides access to these features. Section 8 provides a listing of the Hand Held Terminal interface.

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6.2 T200 Functionality Overview

The following section gives an overview of T200 functional options.

6.2.1 Analog Command Interface

The T200 provides a ±10 analog command interface. In this interface mode the T200 accepts a torque, velocity or position command.

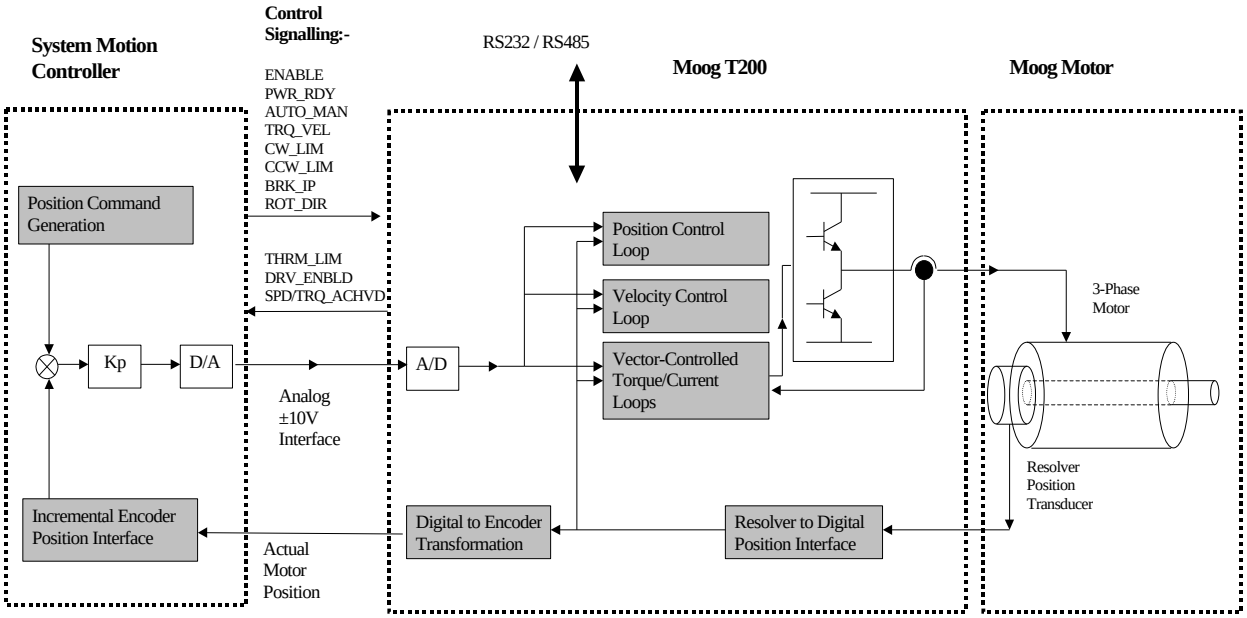

Figure 6.1:- Analog Command Mode System Diagram

Note that the ENABLE, PWR_RDY and AUTO_MAN inputs are used consistently for all control modes.

- The user selects the control mode as torque, velocity or position control, via the user interface. When the T200 is programmed in velocity mode, the T200 may be switched on the fly between velocity and torque mode, via the TRQ-VEL digital input.
- The user interface provides programmable scaling in position and velocity mode. In torque mode, 10V scales to the maximum torque achievable from the motor and Servo-drive combination. In velocity mode the user can program the velocity at which the motor will rotate for a 10V input. In position mode the user can also program the shaft position to which the motor will move for a 10V input.
- The scaling of the Actual Motor Position feedback from the T200 to the System Motion Controller is set via the user interface.
- Control of drive power conditions and feedback of status information is achieved through digital input and output interconnections.
- High speed Torque Limiting is available, through an additional analog interface, for all modes of control.
- Hardware limit switches are available. The rate at which the T200 slows down the motor, when a limit switch is activated, may be programmed by the user.

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6.2.2 Controller Area Network (CAN) Interface Mode

The T200 provides a CAN fieldbus connection. The CAN interface provides:-

- Set-up of all drive parameters using a standard communications protocol (CANOpen).
- High-speed transfer of process and status information. This removes the need for extensive interconnect between the T200 and the System Motion Controller.

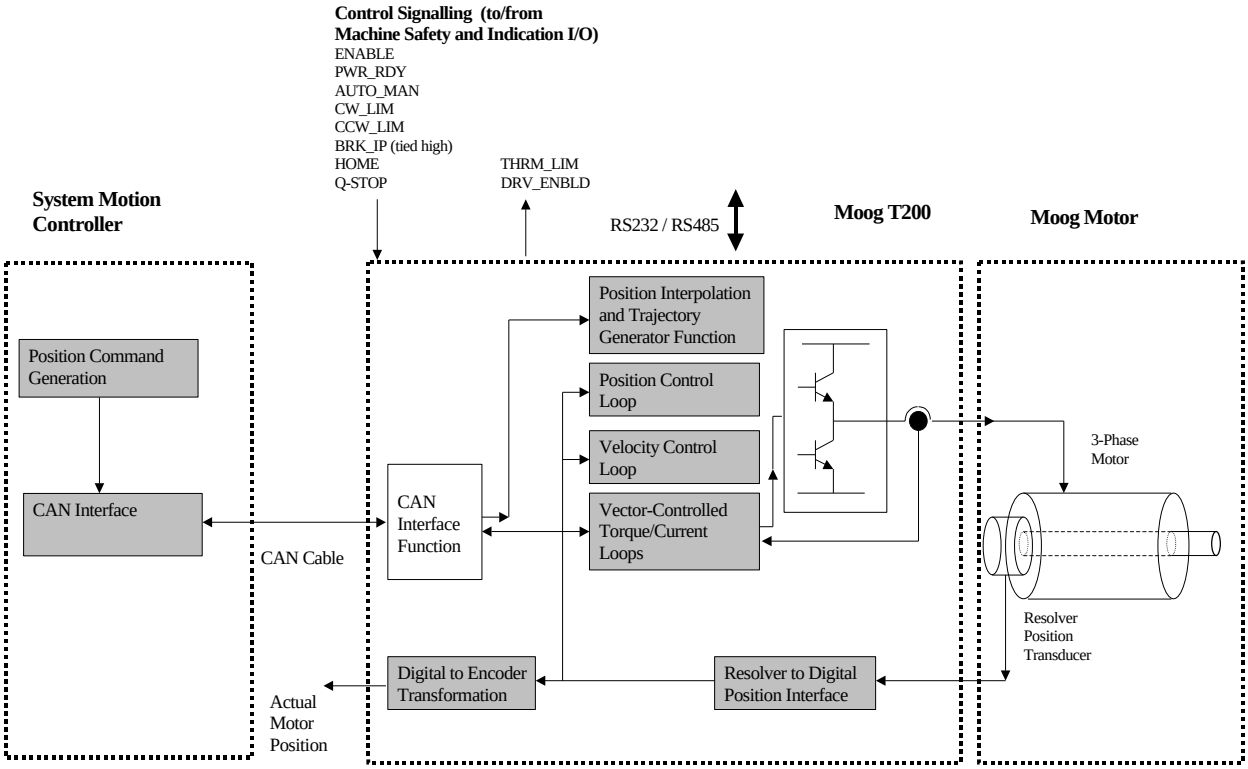

Figure 6.2:- CAN Interface Mode System Diagram

Note that the ENABLE, PWR_RDY and AUTO_MAN inputs are used consistently for all control modes.

- Each T200 has network node identification switches provided on their front panel, such that each node may be addressed uniquely via the CAN interface
- Motor configuration, control modes, control loop gains and other parameterisation information can be read from and written to the T200. Extensive diagnostic information and fault history data can also be read back and analysed by the System Motion Controller. Data sequences can be logged using complex trigger conditions and transmitted back to the System Motion Controller.
- The T200 provides several positioning and velocity modes when operated via the CAN interface:-
  1. *Interpolation Mode*. The System Motion Controller transmits target positions at high data rates, and the T200 finely interpolates these positions to follow the target trajectory.
  2. *Point to Point Mode*. The System Motion Controller transmits a target position, velocity and acceleration via the CAN interface. The T200 generates a smooth trajectory to the target position using this data.
  3. *Gearing Mode*. A 'master' T200 generates a 'Master-Angle' position reference at a high rate. One or many T200 'slaves' receive this reference. These slaves multiple the 'Master-Angle' by a user programmed factor, and use the result as their command position.
  4. *Camming Mode*. Slave T200's simulate a mechanical cam with high precision. Slave T200's transform the 'Master-Angle' through a user defined cam shape, and use the result as their command position.
  5. *Velocity Mode*. The T200 operates in velocity mode, with the command velocity and torque limit transmitted at high speed via the CAN interface.

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- An internal home position routine can be called to reference the T200 position to the machine
- A Jog function is provided to aid in machine start-up and positioning.
- Software limits are provided for position, velocity and torque. Hardware limits are also provided for position.
- Extensive T200 status information is transmitted regularly at high speed via CAN. Status information is also available through digital outputs, if required.

CAN Profile and Interpolation modes are described in detail in additional documents:-

1. CAN Protocol for Interpolation Mode and
2. CAN Protocol for Profile Mode

These documents are available on request from Moog Sales Outlets (See Section 11 for addresses and phone numbers).

6.2.3 Stepper Motor Interface Mode

The T200 provides emulation of a stepper motor interface.

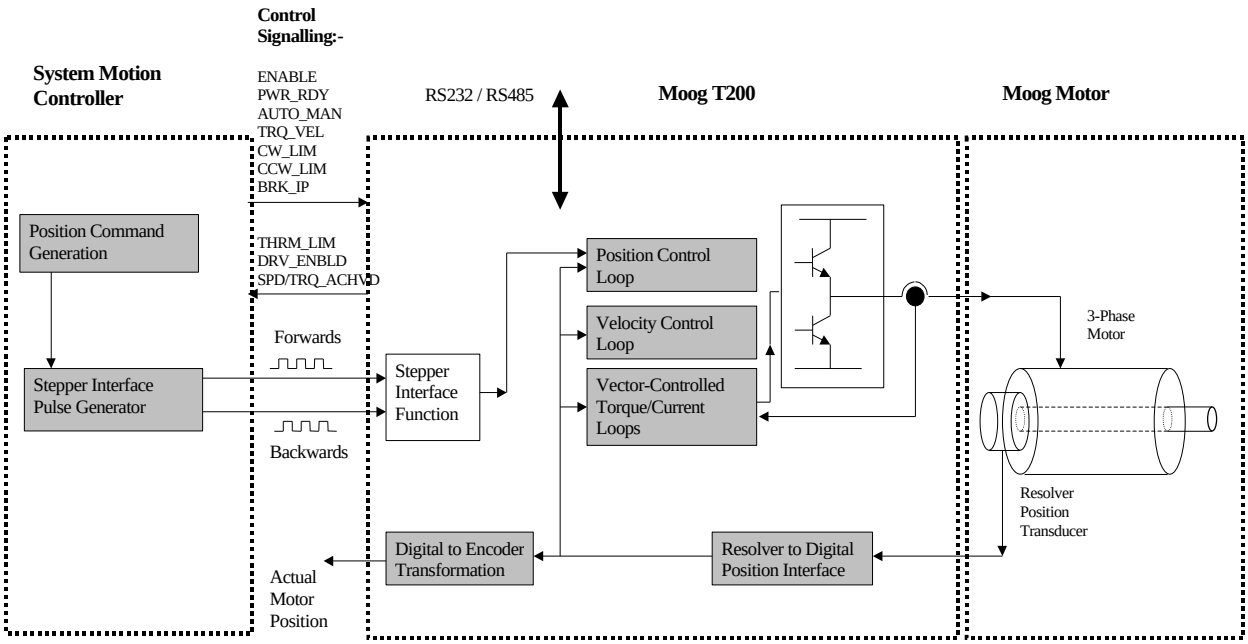

Figure 6.3:- Stepper Interface Mode System Diagram

Note that the ENABLE, PWR_RDY and AUTO_MAN inputs are used consistently for all control modes.

- The T200 accepts pulse rates of up to 1MHz, using an RS422 interface. Pulses are incremented in high speed counter circuitry, so that reference pulses are never lost.
- The user may scale the number of steps per revolution of the motor shaft. The scaling can be set in steps of 128 to 8192 steps/revolution.
- Quadrature and Step/Direction format input pulses are accepted.
- Hardware limits are available.
- High speed Torque Limiting is available, through the additional analog interface.
- Status information is available through digital outputs, if required.
- The drive behaves as a standard stepper interface in other respects. In particular position homing is the responsibility of the user.

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6.2.4 Digital Inputs Velocity Interface Mode

The T200 generates its velocity command as a function of the state of two digital inputs.

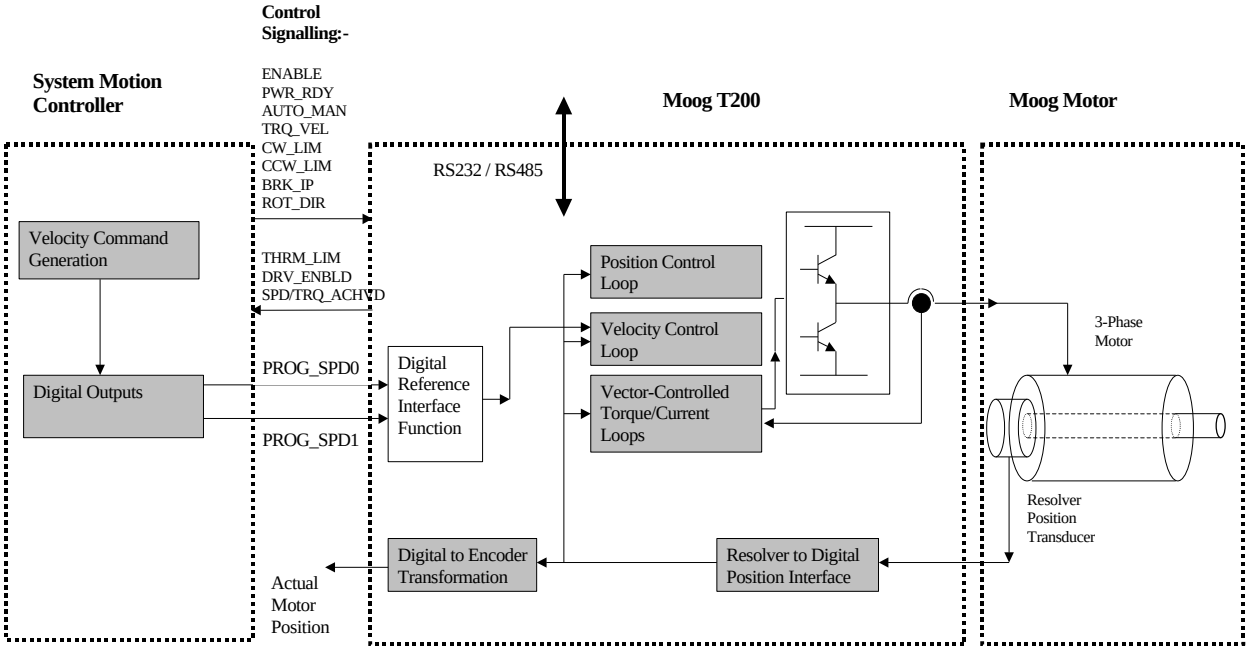

Figure 6.4:- Digital Velocity Reference Mode Block Diagram

Note that the ENABLE, PWR_RDY and AUTO_MAN inputs are used consistently for all control modes.

- The user can program the 4 speeds at which the T200 can be operated.
- The drive behaves as a standard analog interface drive in other respects, as described under Section 6.1.1.

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6.2.5 Standalone Motion-Controller Custom Interface Mode ("Point")

The T200 provides a standalone motion control capability. Contact Moog sales offices for further information on the Point software option.

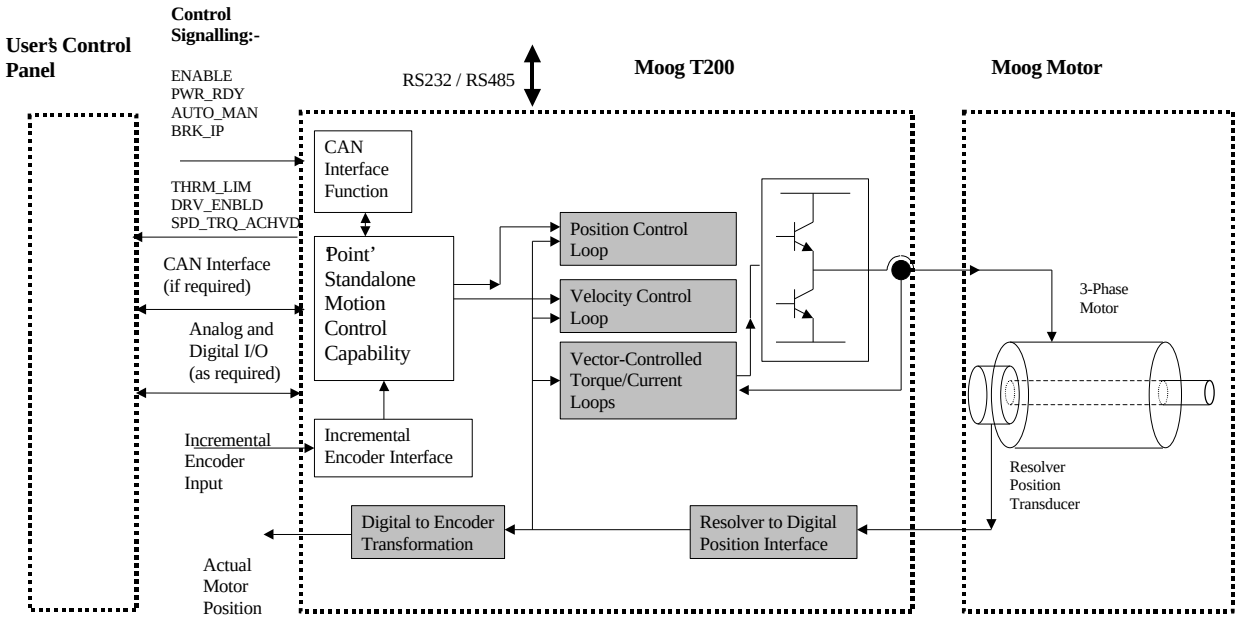

Figure 6.5:- Point Mode Block Diagram

Note that the ENABLE, PWR_RDY and AUTO_MAN inputs are used consistently for all control modes.

- The user can choose from a suite of function blocks called Servo-Control-Algorithms (SCA's). The user may interlink the inputs and outputs of these function blocks to create control loop configurations. The user may use analog and digital inputs and outputs as inputs and outputs of these function blocks.
- A Motion Control Language (MCL) program can be created using a BASIC like language. This language includes a set of arithmetic and logical operators, user variables and other constructs. All T200 input and output, including CAN interface variables, can be accessed from this motion control language.
- Programmable Logic Controller (PLC) functionality is available through the configuration of logic processing blocks. PLC functionality is available through the MCL and the SCA's, for background (pre-empted) motion control programs and as high priority function blocks.
- All CAN operation parameters are accessible via user configurable parameters. The user can then direct CAN high speed I/O to and from SCA function blocks. Through this mechanism interconnections can be made between multiple T200's operating in stand-alone motion control mode.
- An incremental encoder interface is provided. It can be accessed from the motion control interface and the SCA's through a set of user-configurable parameters.
- An internal home position routine can be called to reference the T200 position to the machine.
- A jog function is provided to aid in machine start-up and positioning.
- Software limits are provided for position, velocity and torque. Hardware limits are also provided for position.

The Point option is outlined in the T200 Point User's Manual.

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6.3 T200 Conventions

This section deals with commonly understood conventions for T200 operation.

6.3.1 Direction of Rotation

The positive direction of rotation is clockwise, when the motor is viewed from the shaft end, as shown in the diagram below.

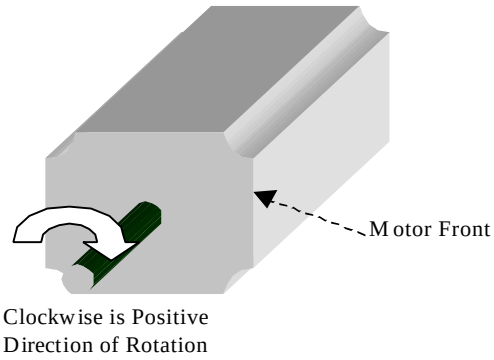

Figure 6.6:- Rotational Convention for Mechanical Process Variables

The direction convention applies to all torque, velocity and position variables. For example a positive analog torque command should tend to rotate the motor in a clockwise direction when viewed from the shaft end.

CAUTION:- Position, Velocity and Torque variables transferred via Controller Area Network interfaces have the OPPOSITE polarity to that listed above. CAN position related variables increase numerically as the motor rotates in a COUNTER-CLOCKWISE direction.

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6.4 Power Interface Section

6.4.1 T200 Model Types and High Power Interface

Two basic types of the T200 are available:-

1. The T200-X**1**0 models accept a.c. mains inputs with a nominal voltage level from 120Va.c. to 230Va.c. (where X stands for a digit between 3 and 5). The T200-610/710 models accept a.c. mains input with a nominal voltage level of 230Va.c.. The T200-310, T200-410, T200-510, T200-610 and T200-710 models include integrated high voltage power supply, control and motor power sections.
2. The T200-X**0**0 models accept d.c. inputs with a voltage level from 30Vd.c. to 400Vd.c. (where X stands for a digit between 3 and 5). The T200-300, T200-400 and T200-500 consist of control and motor power sections only.

The exact type of T200 which the user will require will depend upon the type of application:-

- For single axis applications, a Servo-drive with integrated high power supply must be used (T200-X10).
- For multiple- axis applications, a unit with integral PSU supplies D.C. Bus high power to units without an integral PSU (T200-X10 with several T200-X00 units).

6.4.2 High Power Section Description

The high power supply section has the following features:

- Single or Three Phase a.c Operation.
- Direct Off-Line 120Vr.m.s. to 230 V r.m.s Operation.
- Soft Start (a.c. Inrush Current Limiting).
- Input MOV Transient Protection.
- Internal 40W Regeneration capability, protected by an electronic circuit breaker (T200-310/410/510 models only).
- Fast Bus Discharge.
- Power Ready Relay.
- Provision for External Regeneration Resistor.
- Integral Shunt Regulator.
- Integral Heat Sink and Cooling Fans.

These features are described in the next sections.

WARNING - The high power section contains large capacitors that maintain high voltage on the d.c.+ to d.c.- terminals for several minutes after input power is removed, if the regeneration circuit is not operating normally. Wait at least 5 minutes after power shutdown for capacitors to discharge. Then use a voltmeter to check for safe voltage from the d.c.+ terminal to the d.c.- terminal before contacting terminals or commencing any service or maintenance activities to ensure no lethal voltages are present. Failure to follow this procedure may result in serious personal injury or death.

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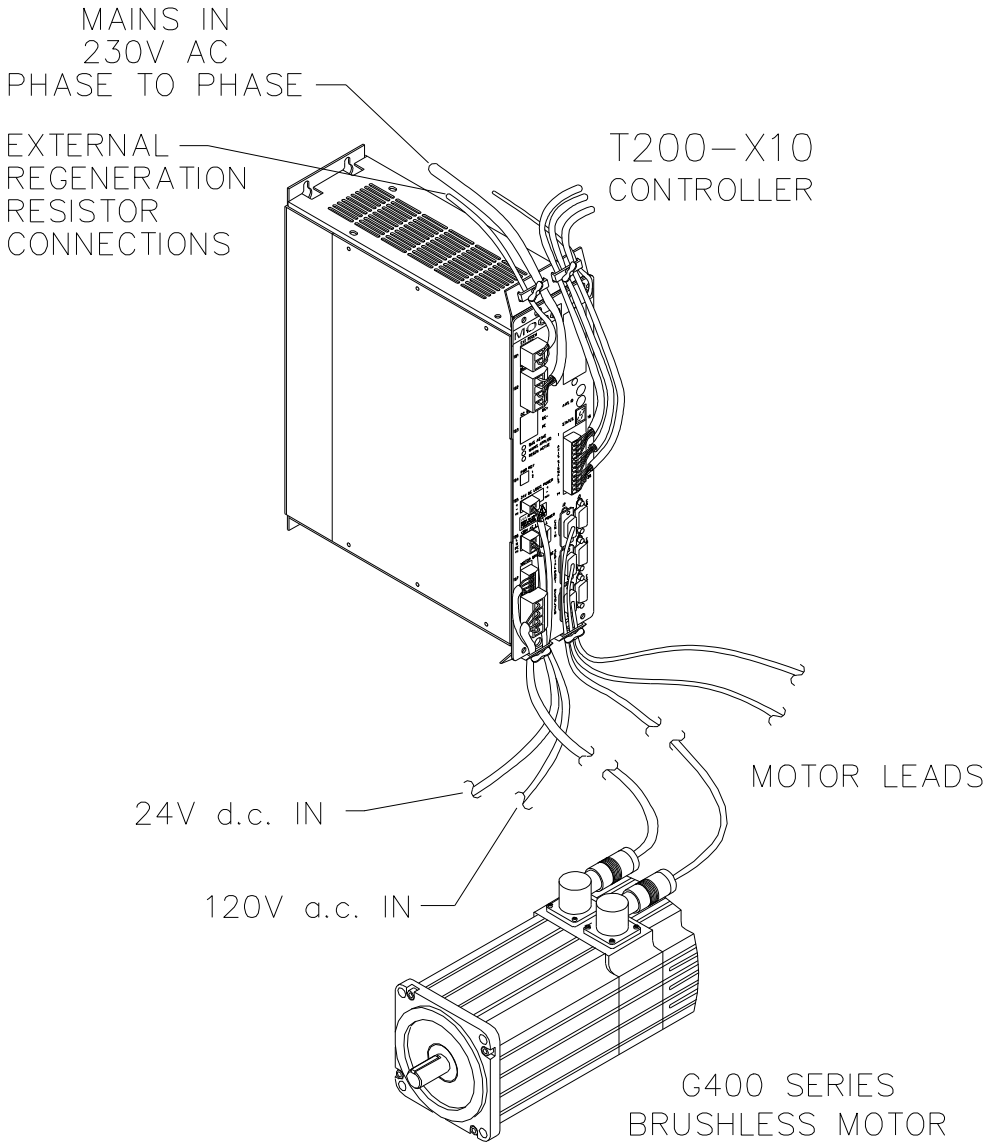

Figure 6.7:- T200-X10 in Single-Axis Application

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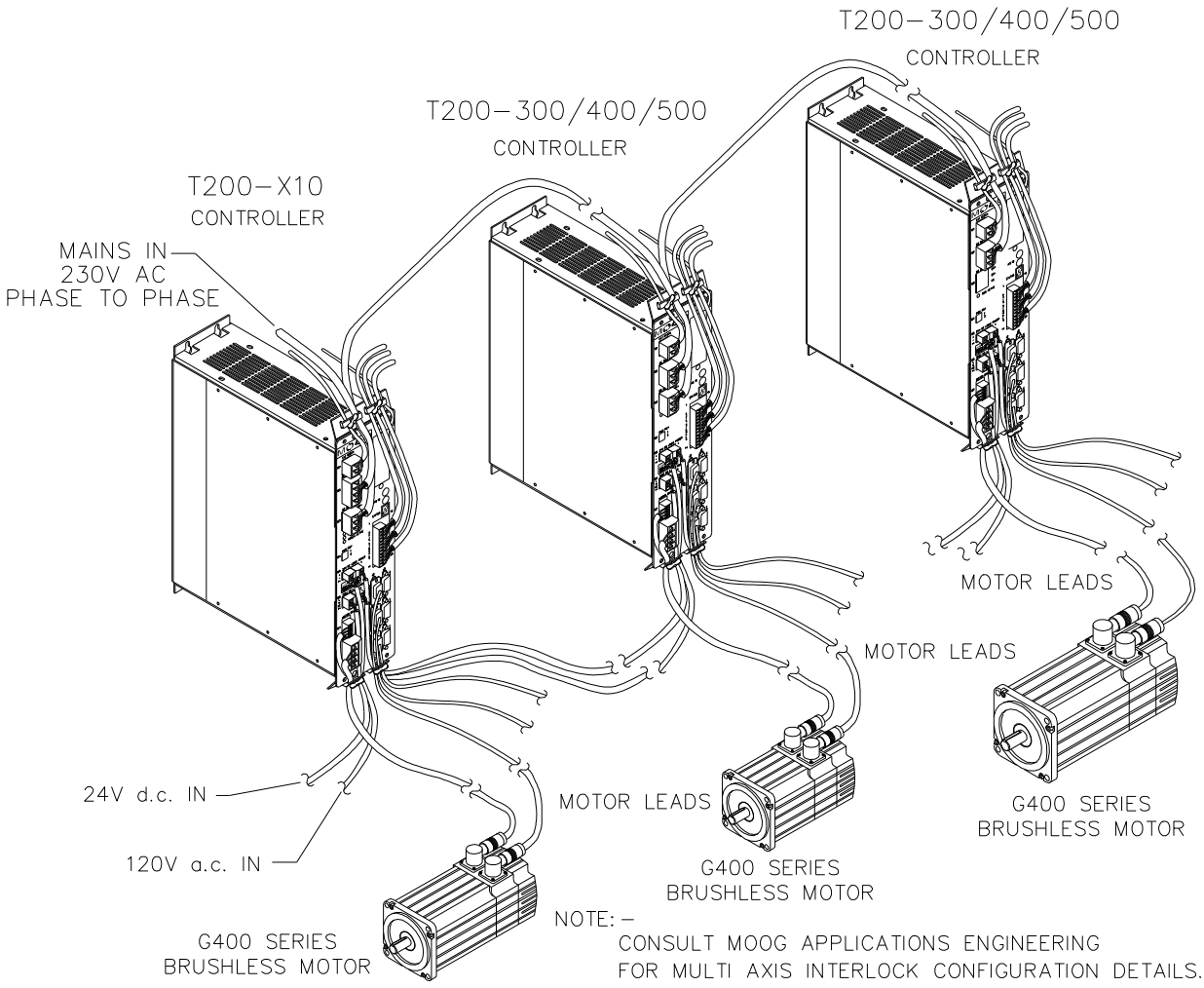

Figure 6.8:- T200-X10 in Multi-Axis Application

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6.4.2.1 High Power Circuit Description

The high power supply section may be divided into functional blocks:

- High voltage rectification and filtering
- Soft-start of a.c. mains power-on
- Low voltage control power supply
- Regeneration circuit
- Monitoring and fault logic circuits

a) High Voltage Rectification and Filtering

The a.c. mains input is rectified by a three phase diode bridge and filtered by a bank of electrolytic capacitors to generate a nominal 325 V d.c. supply. This high power 325 V d.c. supply is unregulated and will vary in direct proportion with the a.c. mains input voltage magnitude.

A.C. Mains Type	D.C. Bus Voltage Level
230V Single and Three Phase Mains	325Vd.c.
120Va.c. Mains	170Vd.c.

Table 6.1:- Magnitude of the D.C. Bus

b) Soft Start

Soft start is used to limit the inrush current to the d.c. bus capacitor bank on application of a.c. mains power. This is intended to prevent nuisance tripping of circuit breakers or blowing of line fuses on power-up.

The soft start relay will close when the monitoring circuit senses that the high-voltage d.c. bus has charged up to close to the value of the rectified a.c. mains.

Section 3.10 provides details on how the soft-start circuitry functions when T200-X00's are connected to a T200-X10 via the D.C. Bus.

c) Low Voltage Control Power Supply

Control power for the logic circuits is generated by a DC/DC converter, which provides control-circuitry power that is isolated from the mains input. This control voltage also powers the cooling fans. The DC/DC can generate control power from three sources

1. D.C. Bus if it is greater than 250Vd.c.
2. 24Vd.c. external supply which is provided by the user specifically for control-backup power.
3. Isolated 120Va.c. external supply which is provided by the user specifically for control-backup power.

The T200 will always generate power internally from the D.C. Bus (if its voltage is greater than 250Vd.c.) even though the 24Vd.c. and/or the 120Va.c. control-backup supplies are present.

d) Regeneration Circuit

Rapid motor deceleration or an overhauling load creates a situation in which energy is returned back into the D.C. Bus. The Regeneration energy will charge up the power supply bus capacitors, causing their voltage to increase. To prevent capacitor overvoltage, a shunt regulator circuit senses when the bus voltage exceeds the Regeneration cut-in voltage and switches a Regeneration resistor across the D.C.Bus, (via a Regeneration transistor) to dissipate the Regeneration

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energy. The frequency at which the Regeneration circuit operates is dependent upon the magnitude of the Regeneration energy.

The internal Regeneration resistor is protected by an internal electronic circuit breaker which disables Regeneration when the internal resistor's rating is exceeded.

If the Regeneration energy exceeds the capacity of the internal Regeneration circuit, a higher capacity external Regeneration resistor must be used. Section 3.13 described how to install such a resistor. If the external resistor's rating is exceeded, the T200 Servo-drive reports a warning to the user, via both the 7-segment display (U6 or E6 warning) and the activation of the THRM_LIM digital output.

A suitably rated fuse to short-circuit protect the external Regeneration resistor is fitted internally in the T200-310, 410 and 510 servo-drive. The fuse is sized to protect the external resistor option available for that particular T200 model, as described in Section 3.13. The user should not change this fuse. If this fuse is blown, then the T200 must be returned to Moog for repair. For T200-610 and T200-710 servo-drives, the fuse must be provided externally.

For further information regarding the implemented regen resistor protection scheme see section 6.8 - Self Protection.

e) Monitoring and Fault Logic

When a.c. mains power is first applied to the PSU, the inrush charging current is limited. When the T200 senses that the D.C. Bus has been charged up, the Soft Start Relay energises to switch the power supply into its normal configuration. Note that a blown Regeneration fuse or an open internal Regeneration resistor will prevent the power supply from starting up, and generate a fault indication ('F3' on the 7-segment display) .

When a.c. power is removed, a fast discharge of the D.C. Bus occurs discharging internal high voltages.

WARNING. The fast bus discharge circuitry may become damaged during operation, or may not be operational if the F3 fault is active. The user should still wait for 5 minutes after all power has been removed to begin service operations on the T200.

A thermistor on the high power section heatsink is used to generate a PSU Over-temperature fault if the temperature of the a.c. mains rectification circuitry exceeds its rating.

A fault condition is caused by any of the following:

- Regeneration Fuse Blown. The internal regeneration resistor fuse has been blown. Fault F3 is displayed on the 7-segment display. The unit must be returned to Moog for repair.
- PSU Thermal Fault:- The Bridge Rectification Circuitry Heatsink temperature is excessive. Fault F4 is displayed on the 7-segment dispay.
- Bus Overvoltage:- The D.C. Bus voltage exceeds 410Vd.c. The fault code F2 is shown on the 7-segment dispay.

Any faults detected are relayed to the control electronics where the appropriate diagnostic message will be displayed on the seven segment display and appropriate action taken. T200 operation under fault conditions is described in Section 6.7.

High Power Section System Sequencing
High power sequencing is described in Section 3.10.

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6.5 Input and Output Functional Description

6.5.1 *Reference* Analog (±10V Command) Input

The Reference Analog Input is a ±10V differential analog Torque or Velocity command input from a System Motion Controller. The Reference input is also used for general motion control purposes by the Point Motion Control sub-system. Section 3.15 outlines the electrical characteristics of the analog inputs. Note that in the velocity and torque modes of control, the polarity of commanded movement can be inverted by use of the ROT_DIR digital input (see Section 3.15).

In torque and velocity mode, calculations based upon the Reference are carried out and the actual motor torque modified within a maximum of 430microseconds of the Reference being sampled.
Scaling of process variables (for example the Velocity-Command) are described in Sections 6.6.1 Torque Mode, 6.6.2 Velocity Mode and 6.6.3 Position Mode.

6.5.2 *Spare* Analog (Analog Torque Limit) Input

The Spare Analog Input is the primary means of measurement of an analog torque limit input from a Motion Controller. It also serves as a secondary means of measurement of an analog command from a master control system. The Spare input is also used for general motion control purposes by the Point Motion Control sub-system, when the T200 is configured in that mode. Section 3.15.3 outlines the electrical characteristics of the analog inputs.

In torque, velocity and position mode, calculations based upon the Spare are carried out and the actual motor torque modified within a maximum of 8milliseconds of the Spare being sampled.
The use of the Analog Torque Limit is described in more detail in Section 6.7.1.6 Analog Torque Limiting in Torque Mode.

6.5.3 *TP1* Analog Output

The TP1 Analog Output is used principally for diagnostic purposes. It can be programmed with a series of internal software process variables which can be used to monitor and tune the T200. Section 3.15 outlines the electrical characteristics of the analog outputs.

The following internal software variables may be monitored on TP1:-

1. **Torque**: The internal current command can be monitored. This is scaled as 10V= (min)(Motor Peak Current and Drive Peak Current).
2. **Commanded Velocity**:- The velocity command can be monitored on TP1. This is scaled by the user-programmable RPM-per-10V parameter.
3. **Actual Velocity**:- The actual velocity (feedback) can be monitored on TP1. This is scaled by the user-programmable RPM-per-10V parameter.
4. **Velocity Error**:- The velocity error can be monitored on TP1. This is scaled by the user-programmable RPM-per-10V parameter.
5. **Reference Position**:- The position command can be monitored on TP1. This is scaled by the user-programmable Revs-per-10V parameter. The T200 contains a special function to zero-reference the present shaft position, such that this position is taken as the zero-voltage-point of TP1 and TP2.

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6. **Actual Position**:- The position feedback can be monitored on TP1. This is scaled by the user-programmable Revs-per-10V parameter. As before, the T200 contains a special function to zero-reference the present shaft position, such that this position is taken as the zero-voltage-point of TP1 and TP2.
7. **Position Error**:- The position error can be monitored on TP1. This is scaled by the user-programmable Revs-per-10V parameter.
8. **Filtered Actual Velocity**:- The actual position is filtered using a first order filter. The filtered velocity can be monitored on TP1 and is scaled by the user-programmable RPM-per-10V parameter.
9. **Observer Estimated Velocity**:- The velocity-observer's estimation of present motor velocity can be monitored on TP1. This is scaled by the user-programmable RPM-per-10V parameter.
10. **Observer Estimated Error**:- The velocity-observer's estimation of present motor position error can be monitored on TP1. This quantity is un-scaled and is displayed in internal software units.
11. **Point Diagnostic Channel 1**:- The Point Motion Servo-drive can utilise the analog outputs as flexible output channels. Note that the user MUST program TP1 as the Point Diagnostic Channel 1 parameter, in order to display Point parameters.

TP1 Display Latencies for Software Variables

- **Measured process variables** (***actual velocity*** (item 3) and ***actual position*** (item 6)) are displayed within **200microseconds** of their equivalent analog signals' sampling and conversion to digital form.
- **Derived process variables** (all other items of the list above) are displayed within **550microseconds** of the commencement of the process cycle within which they were calculated.

6.5.4 *TP2* Analog Output

The TP2 Analog Output is again used principally for diagnostic purposes. The same internal software variables can be programmed on TP2 as on TP1, with the exception that item **11** corresponds to **Point Diagnostic Channel 2** rather than **Point Diagnostic Channel 1.**

TP2 Display Latencies for Software Variables are the same as those of TP1.

6.5.5 Limit Switch Function

Limit switches are used to stop the motion of the motor outside permissible machine operation limits. A Limit Switch is active when no current flows in it's digital input.

1. **Torque Mode**:- Activation of the Clockwise Limit switch will inhibit torque production in a clockwise direction. Likewise activation of the Counter-Clockwise Limit switch will inhibit torque production in a counter-clockwise direction.
2. **Velocity Mode**:- Activation of the Clockwise Limit switch will cause the velocity command to be ramped down at the rate Emergency-Deceleration-Rate, to zero velocity, and will subsequently clamp the velocity command to zero. Motion in the Counter-Clockwise direction may still continue, in the absence of activation of the counterwise-clockwise limit switch simultaneously! Likewise activation of the Counter-Clockwise Limit switch will cause the velocity command to be ramped down at the rate Emergency-Deceleration-Rate, to zero velocity, and will subsequently clamp the velocity command to zero. Motion in the Clockwise direction may still continue, in the absence of activation of the clockwise limit switch simultaneously!
3. **Position Mode**:- The exact reaction to the Limit Switches depends upon the command generation mode:-
   - In **Analog Position** mode and **Stepper Interface** mode the reaction to the limit switches is the same as the reaction in Velocity Mode.

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- In **CAN Profile Mode**, activation of either limit switch will cause the T200 to perform a servo-stop, return to Point to Point mode from whatever mode it was previously in, and allow motion in the opposite direction to the direction of the active Limit Switch.
- In **CAN Interpolation Mode**, the limit switches are ignored.
- In **Point mode**, it is the responsibility of the user to use appropriately program use of Limit Switch type inputs.

Software Latency to Limit Switch Activation:- Software, where specified to react to Limit Switch activation, will start a suitable reaction in less than 8ms of limit switch activation

6.5.6 Power Ready Input

The Power Ready input is only used by T200 units which do not have an integral PSU i.e. T200's with Model Number T200-X00.. , though the input is present in all T200 units. The Power Ready input informs the T200-X00 that the T200 which is supplying it with high-power via the rectified high voltage DC-Bus, is ready to deliver such power, after a mains power-on sequence has been successfully completed. If the T200-X00 were to start drawing high power before the connected T200-X10 was ready, fuse-blown or other electrical damage to the T200-X10 might result because of thermal overstress of softstart components.

See Section 3.10 for further details on interconnections between T200 units which share a high-voltage Power Supply.

Software Latency to Power Ready State:- The T200 software will disable the high power section in less than 8ms of no current flowing in the Power Ready input.

NOTE:- A T200-X00 unit will NOT allow its high power section to be enabled if the Power-Ready input is not active.

6.5.7 Automatic and Manual Power Settings

The T200 provides a lower power mode for user safety reasons. This mode is called **Reduced-Power** or **Manual** mode. The T200 is switched into this mode by the status of the AUTO_MAN digital input.

- **Manual Mode**:- If no current flows in this input, the T200 is placed in Manual Mode. In this mode the T200 uses the Manual_Mode_Torque_Limit and the Manual_Mode_Velocity_Limit.
- **Automatic Mode**:- If current flows in the digital input then the T200 is placed in Full-Power Mode or Automatic Mode. In Automatic Mode the Automatic_Mode_Torque_Limit and the Automatic_Mode_Velocity_Limit apply.

Software Latency to Auto-Man State:- The T200 software will change the torque and velocity limits in less than 8ms of a change of state of the Auto_Man digital input.

CAUTION:- the user can program the MANUAL_MODE torque and velocity limits to be higher than the same limits in the AUTOMATIC_MODE. The user should ensure that the correct limits are set-up in the T200 software, so that inadvertently limits are not swapped or used incorrectly in either MANUAL or AUTOMATIC states.

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6.5.8 Torque-Velocity Control Mode switching

The TRQ-VEL digital input is used to switch the T200 from velocity mode to torque mode and back. This feature is useful in nut-running and other applications. The TRQ-VEL input is only used when the user programs the T200 control compensator to Velocity Mode. If the user programs either Torque or Position mode, then this input will be ignored.

The T200 will be placed in torque mode when current flows in the TRQ_VEL input. If no current flows, then the T200 will stay in or return to velocity mode.

When the T200 changes from torque control to velocity control, all velocity loop compensation variables are zeroed. In particular the integral term of the velocity PI compensator is set to zero.

Software Latency to TRQ_VEL:- The T200 software will change the control mode in less than 8ms of a change of state of the TRQ_VEL digital input.

6.5.9 Rotation Direction

Section 6.2.1 Direction of Rotation outlines the convention for positive direction of rotation. This convention is reversed for the analog reference (REF±) input and for the Programmable Speed function described in Section 6.4.10, when the ROT_DIR digital input is activated. When current flows in the ROT_DIR input, the convention for the torque or velocity command will be reversed.

Software Latency to ROT_DIR:- The T200 software will change the direction of rotation in less than 1ms of a change of state of the ROT_DIR input, in control modes where this digital input is actually used by software

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6.5.10 Programmable Speed Functions

The T200 provides a velocity command mode, in which the state of two digital inputs is used to command the motor to rotate at one of four user-programmed speeds.

The reference speeds are specified in units of RPM and can be positive or negative. Note that the programmable speeds is influenced by the ROT_DIR input as described in Section 6.4.9 Rotation Direction.

PROG_SPD_ 1 Status	PROG_SPD_ 0 Status	Speed Reference Used
0 (no current)	0 (no current)	Digital Input Reference 0
0 (no current)	1 (current)	Digital Input Reference 1
1 (current)	0 (no current)	Digital Input Reference 2
1 (current)	1 (current)	Digital Input Reference 3

Table 6.2 Digital Input Speed Programming

6.5.11 Thermal Limiting Indication

The Thermal Limit active THRM_LIM is used to indicate if one of the following sources of current limiting has decreased the overall thermal current limit to the extent that the current allowed is less than that demanded.

- **Power Amplifier Thermal Protection**:- The Thermal Limit output is opened (no current flowing) if the demanded current is greater than that allowed to ensure the power electronics junction temperatures are less than the manufacturer's recommended maximum (usually 150°C) less a considerable safety margin.
- **Motor Thermal Protection**:- The Thermal Limit output is opened (no current flowing) if the demanded current is greater than that allowed to ensure the temperature of the motor windings is kept to a safe limit (155°C).
- **RMS Current Protection**:- The Thermal Limit output is opened (no current flowing) if the demanded current is greater than that allowed to ensure RMS current over any averaging period is less than continuous current limit of the T200.
- **Regeneration Resistance Protection**:- The current flowing in the external regeneration resistor is monitored. If the RMS current in the external regeneration resistor within any averaging period exceeds the continuous current rating of the regeneration resistor, then the Thermal Limiting output will be opened.

Software Latency to Thermal Limiting Active:- The T200 software will change the Thermal Limiting output within 8 milliseconds of a current limiting occuring. Note however that motor thermal protection is calculated approximately every 45milliseconds.

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6.5.12 Drive Power Status

The DRV_ENBLD opto-coupler output shows the enabled status of the T200's high power electronics. If the output is closed (current flowing) then the power electronics are applying high power to the motor phases. If the output is open (no current flowing), then the high power has been removed from the motor phases.

Note that the DRV_ENBLD output does not give any indication of the status of power application to the regeneration resistor. It is possible that current is flowing in the regeneration resistor though the DRV_ENBLD output is opened (no current flowing).

Software Latency to DRV_ENBLD:- The T200 software monitors the power electronics status and sets the output according to that status every 8milliseconds.

WARNING:- The user should not attempt to touch T200 high power parts or perform service on the T200 or debug of an application, if he relies on the status of the DRV_ENBLD output alone. In this case he should remove all power, wait 5 minutes for the internal high voltages to dissipate, and then perform the work.

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6.5.13 Speed Torque Achieved Indication

The SPD_TRQ_ACHVD opto-coupler output is used to indicate the status of achieving the programmed set-point command, whether torque or velocity (in position mode this output is used to track the velocity command).

The user programs a Set-Point band, expressed as a percentage of a peak (Tmotor(MAX) in the case of torque Nominal_Speed in the case of velocity). If the error (difference between the setpoint and the actual) is larger than the Set-Point Band, then the digital output will open. If the error is less than the Set-Point Band, then the digital output will close.

The diagram below indicates an extreme case, where the reference velocity is set equal to the programmed set-point velocity. The actual velocity oscillates about the set-point due to poor tuning of a control loop. The digital output turns off and on rapidly until the actual settles to a value close to the set-point.

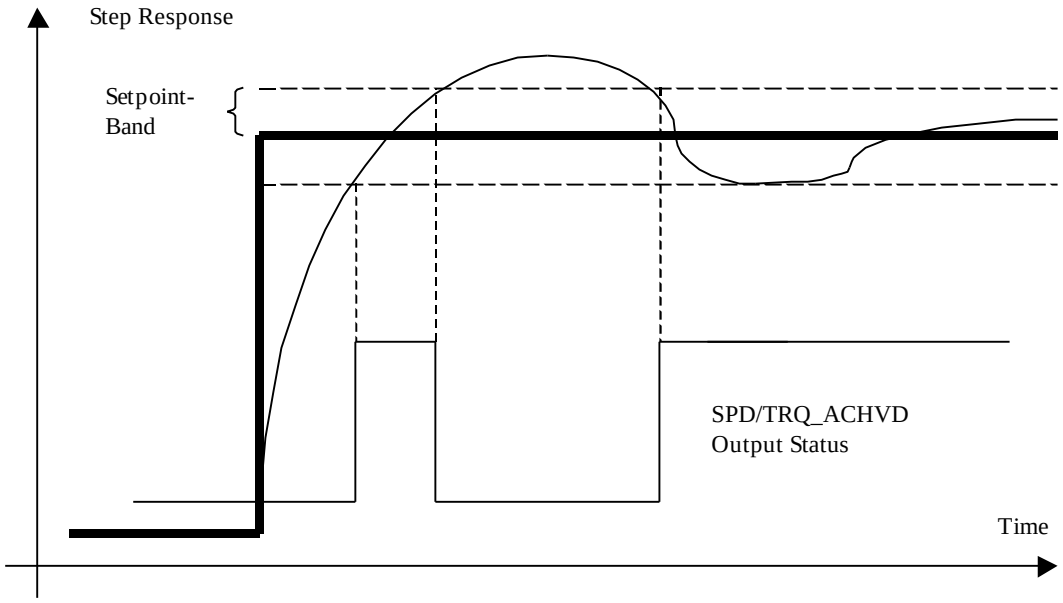

Figure 6.9:- Set Point Achieved Example

Four programmable variables are available to the user:-

- **Torque Setpoint Value**:- The torque setpoint is specified in Nm.
- **Torque Setpoint Band**:- The torque setpoint band is specified in Nm
- **Velocity Setpoint Value**:- The velocity setpoint is specified in RPM.
- **Velocity Setpoint Band**:- The velocity setpoint band is specified in RPM
- **Set-Point Function Enable**:- The set-point detection function can be enabled and disabled using the setpoint enable parameter.

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6.5.14 System Ready Indication

The System-Ready relay output (SYS_RDY±) indicates the error status of the T200. The relay will close when all fatal faults have been removed. It will open when any fatal faults appear.

Note on application of a.c. mains power:-

- The System-Ready relay will close only when the a.c. mains has been applied and all other faults have been removed.

6.5.15 Brake Control

The T200 do have an integrated brake relay which allows the control of the motor brake. The control of the 3.5A, 30Vd.c. relay is dependent on the mode in which the T200 operates. The 24Vd.c. supply voltage for the Motor brake must be supplied by the user and connected to TB7 as described in Section 3.14.2.

- Velocity, Torque, Position Mode
  The relay is user controlled. An active signal on J1/Pin11 causes the relay to close.

- CAN-Mode
  J1/Pin11 must be tied high. The relay can be controlled over CAN.

- Custom POINT Mode
  J1/Pin11 must be tied high. The relay can be controlled in the POINT application program.

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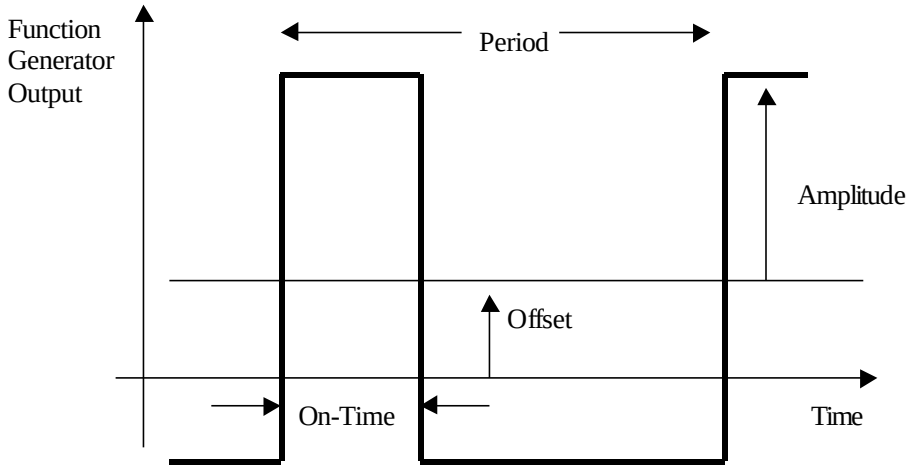
6.6 Internal Function Generator

An internal function generator is provided, which is used to generate square wave excitation signals in torque and velocity mode, and a spline shape in position mode, to aid in control loop tuning and general drive debug work.

6.6.1 Torque and Velocity Function Generator



$$\text{Duty-Cycle} = \frac{\text{On-Time}*100}{\text{Period}}$$

Figure 6.10:- Torque and Velocity Function Generator Output Waveform

In torque and velocity mode a square shaped waveform, with variable amplitude, offset, duty cycle and period is generated as shown above in the diagram.

The following parameters can be set by the user:

- **Speed Amplitude**:- The Speed Amplitude determines motor velocity. The Speed-Amplitude is specified in units of RPM. If the Speed Offset was set to 0, then the Speed Amplitude would set equal magnitudes of velocity command in both the clockwise and counter-clockwise direction. The Speed Amplitude must be a positive number.
- **Speed Offset**:- The Speed Offset is specified in units of RPM. It is added to the Speed Amplitude for one direction of rotation and subtracted for the other direction.
- **Torque Amplitude**:- The Torque-Amplitude is specified in units of Nm. If the Torque Offset is set to 0, then the Torque Amplitude would set equal magnitudes of torque command in both clockwise and counter-clockwise directions. The Torque Amplitude must be a positive number.
- **Torque Offset:-** The Torque Offset is used to bias the torque command in one direction of rotation. Specified in units of Nm.
- **Period**:- The Period determines the time taken for one cycle of operation of the servomotor. It is specified in seconds.

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- **Duty-Cycle**:- The Duty-Cycle determines the length of time the Speed or Torque Amplitude is of a more positive polarity and is expressed as a percentage. For the remainder of the period, the Speed or Torque Amplitude is of a more negative polarity.

CAUTION:- The function generator will apply steps of torque and velocity commands, which may damage machinery due to a sudden jerk. The user is cautioned to start the function generator torque or speed amplitude at a small value and increase it slowly to its intended value, to ensure no damage to mechanical elements of the machine

6.6.2 Position Function Generator

In position mode, an S-shaped position profile is generated, with programmable acceleration, velocity, and position traverse, as shown below in the diagram.

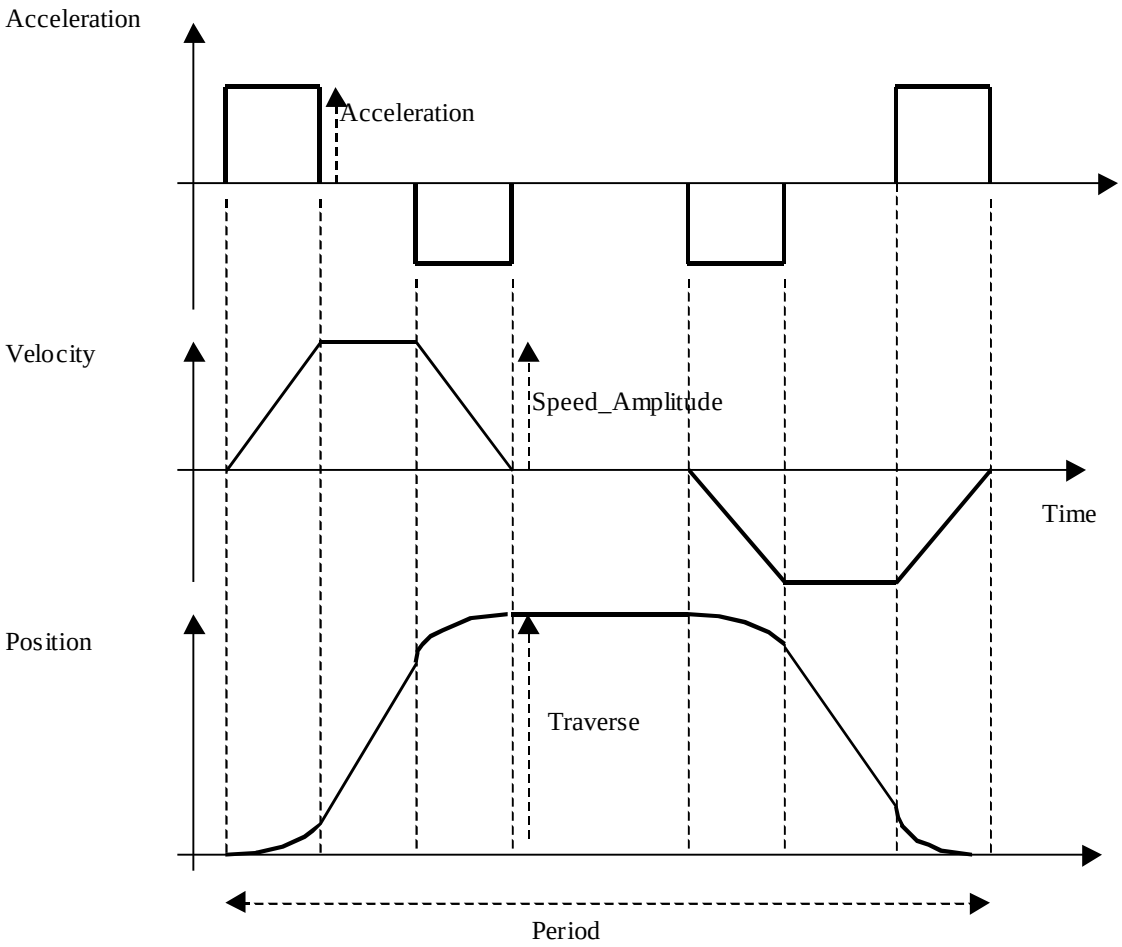

Figure 6.11:- Position Mode Function Generator Output

The following parameters can be set by the user:

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- **Acceleration**:- The Acceleration parameter will set the rate of change of the velocity command during the position traverse. Specified in units of rad/s^2.
- **Speed Amplitude**:- The Speed Amplitude determines maximum motor velocity during the motion. The Speed-Amplitude is specified in units of RPM. If the traverse is short, it is possible that the speed command will not reach the Speed-Amplitude. The Speed-Amplitude is therefore to be interpreted as a maximum speed limit.
- **Period**:- The Period determines the time taken for one there-and-back motion of the servomotor. It is specified in seconds. Note that if the Traverse is long, or the Speed-Amplitude or Acceleration small, then the time taken for one there-and-back motion may exceed the Period.
- **Traverse**:- The magnitude of the motion, expressed in revolutions of the motor shaft, is programmed using the Traverse parameter.

The position function generator must be stopped when any of the motion parameters are to be changed. This is to ensure that the motion does not exceed machine limits, in the case that motion is halted part-ways at a certain position, and recommenced with a full traverse from that position, when the parameters update is complete. Special hand held terminal and user interface commands are provided for this purpose.

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6.7 Control Loop Overview

6.7.1 Torque Mode

The T200 can be operated in torque mode, with several sources of its torque command. In this mode the T200 acts as a simple current amplifier, so that the torque produced by the motor is proportional to the analog command.

WARNING:- DANGER OF UNCONTROLLED MOTOR ACCELERATION

The T200 has specialised motor current compensation. For optimum performance the T200 operates a software model of the current loop. The correct motor electrical parameters are required for this software model. Large errors in the motor parameters can result in uncontrolled motion.

Small torque commands can result in a continuous motor acceleration. The velocity of the motor can increase in an uncontrolled way if no counter-balancing torque is present. The user's control system should ensure that the speed of the motor is monitored, and that a compensating torque command is applied to control the motor speed if necessary.

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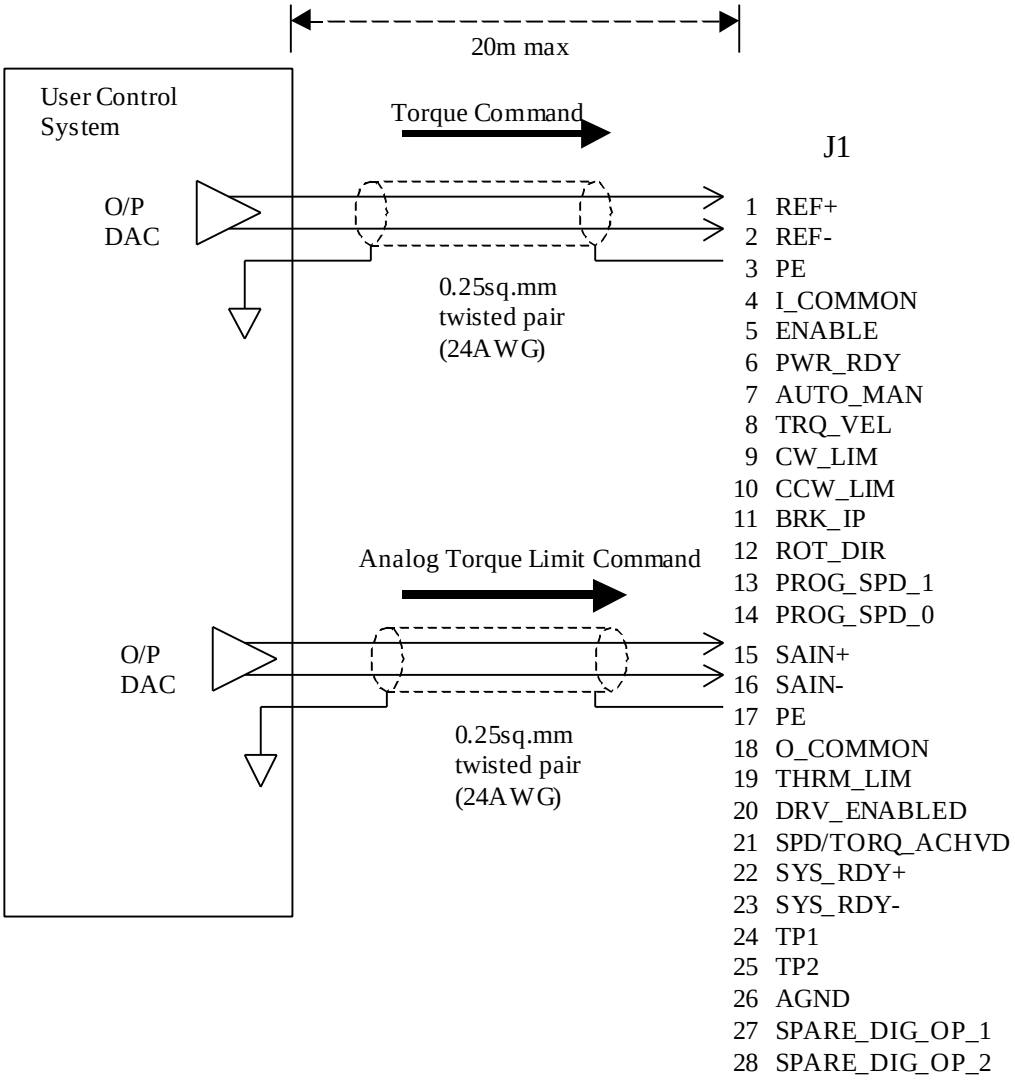

Figure 6.12:- Torque Mode Analog Interconnect

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6.7.1.1 Torque Command Sources

Three sources of torque command may be user-programmed:-

1/ Internal Function Generator. The T200 provides an internal software function generator. The function generator produces rectangular pulses which provide a means of exciting the load, in order to diagnose applications problems or tune the T200. The Torque Amplitude, Offset, Period of excitation and Duty Cycle are programmable. See section 6.5 Internal Function Generator for further information.

2/ Analog Source:- The analog command input is limited to the range ±10V. A 10V command corresponds to full torque. The transfer function from voltage to torque is given by:-

$$\frac{T_{motor}}{V_{in}} = \frac{T_{motor}(MAX)}{10V}$$

where T_{motor}(MAX) is the maximum torque the combination of motor and Servo-drive can produce at the motor shaft. V_{in} is the input voltage.

3/ Point Motion Controller Source:- The T200's integral Point motion controller creates a torque command as an output of loop closure function blocks. This function is available in the 'P' software version only.

6.7.1.2 Torque-Command Analog Offset Adjust

The analog input offset may be adjusted such that the net effect of an offset in the User's Control System and offsets in the T200's input conditioning and Analog to Digital conversion circuitry are cancelled. The T200 provides an automatic mechanism for cancellation of the offset. It is assumed that when the cancellation procedure is invoked, that the present analog command corresponds to zero torque command. The procedure calculates the average of 100 samples of the Analog Digital input, and subtracts this average thereafter from the analog input command.

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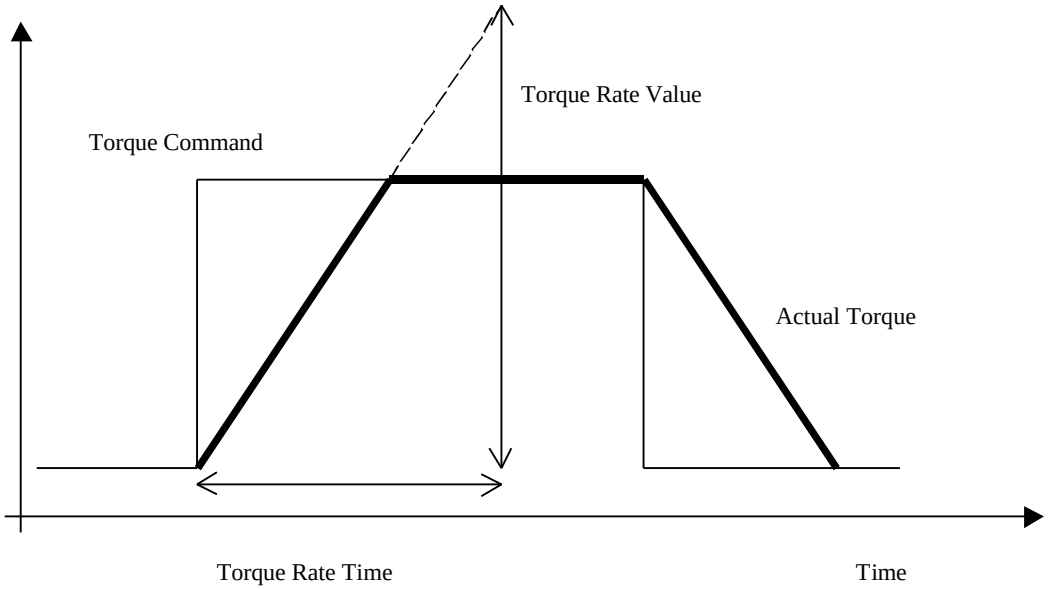
6.7.1.3 Rate Limiting in Torque-Mode

The T200 provides a means of limiting the rate of change of the actual torque. This limits the jerk (rate of change of acceleration) which a sensitive load may experience during acceleration and deceleration phases of a motion.

The user can program the Torque Rate Value (specified in Nm) and the Torque Rate Time (specified in seconds). The maximum allowable rate of change of actual torque is then given by:-

$$\overset{o}{T}\,command\,(MAX) = \frac{Torque\_Rate\_Value}{Torque\_Rate\_Time}$$

Figure 6.13:- Torque Reference Rate Limiting



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6.7.1.4 Programmable Torque Limiting in Torque Mode

The T200 uses the Automatic and Manual Torque Limits as described in Section 6.4.7 Automatic and Manual Power Settings, under the control of the AUTO_MAN digital input.

6.7.1.5 Programmable Velocity Limiting in Torque Mode

In torque mode, the T200 uses the velocity limits. The T200 will try to ensure that the actual velocity never exceeds the particular velocity limit which is effective at the time (which is selected from either the Automatic_Mode_Velocity_Limit and Manual_Mode_Velocity_Limit depending upon the status of the AUTO_MAN input). The limit plus 10% is used as shown in **Figure 6.15**. Velocity limiting is implemented by bringing the torque to zero when the motor actual velocity exceeds the applicable Velocity_Limit. If the user continues to command large accelerating torque, the, T200 will ramp the actual torque back up so that the actual velocity again increases to the limit.

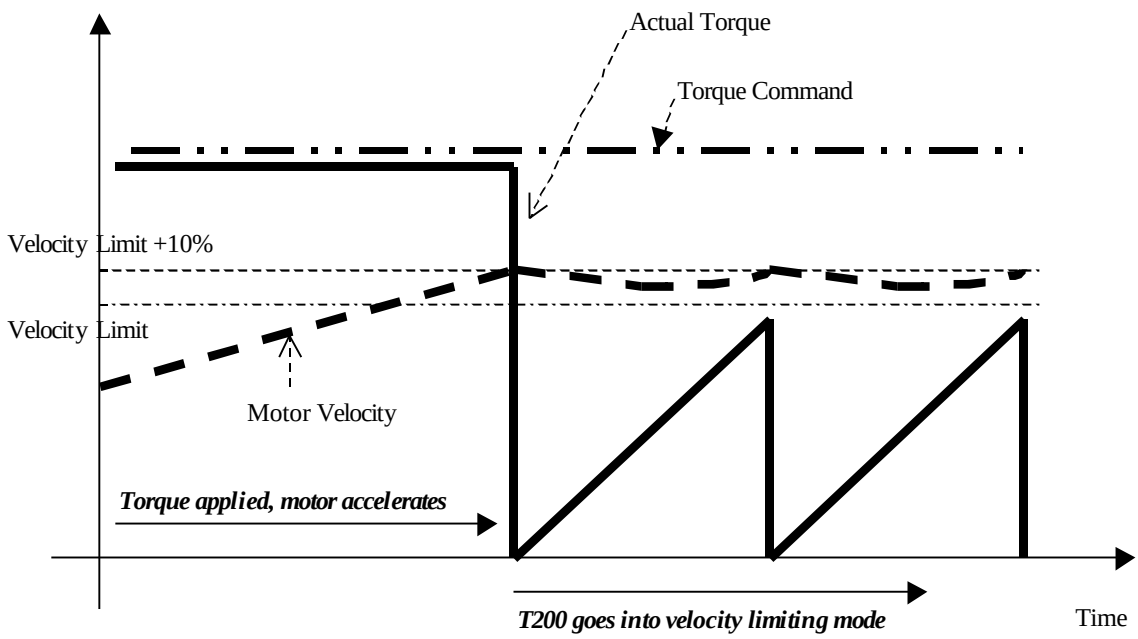

Figure 6.15:- T200 Velocity Limiting Mechanism in Torque Mode

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6.7.1.6 Analog Torque Limiting in Torque Mode

The Spare Analog input (**SAIN**) is used in Torque Mode as a means of reducing the maximum allowable torque in a continuous way. Figure 6.16 below shows the linear relationship between the Analog Torque Limit and the input voltage level between the SAIN inputs.

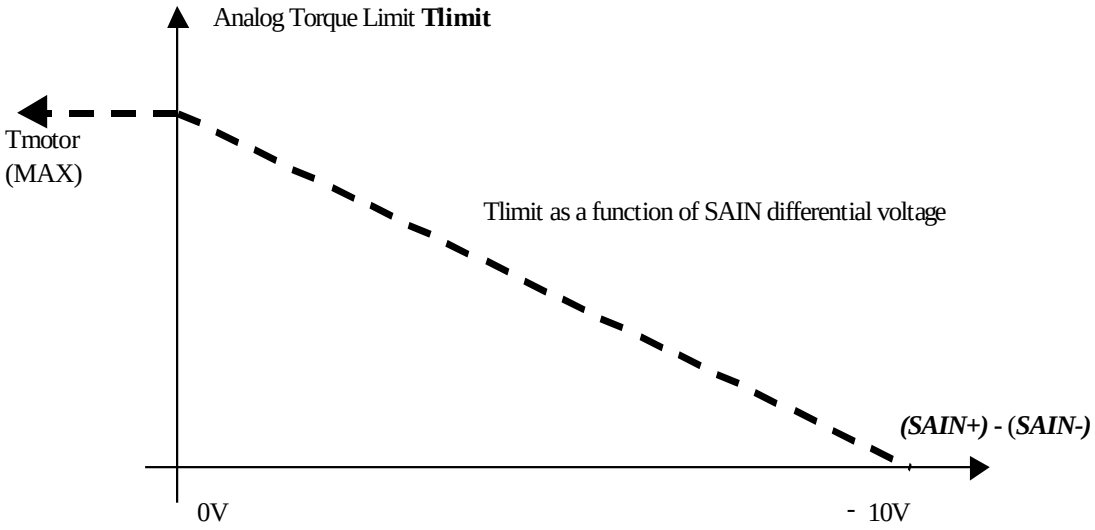

Figure 6.16:- Torque Limit Reduction as a function of Spare Analog Input (SAIN)

- If the SAIN differential voltage is -10V, then the Analog Torque Limit is set to 0Nm. Thus a 10V input will totally zero the motor torque output.
- If the SAIN differential voltage is 0V, then the Analog Torque Limit is set to T_{motor}(MAX). Thus a 0V input will allow maximum motor torque output.
- Note that the electrical and time-related characteristics of the SAIN input pair is defined in Section 3.15.

NOTE:- If the user does not wish to use the Analog Torque Input, then the SAIN input pins can be left unconnected. This results in a zero differential voltage across the SAIN input pair.

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6.7.1.7 Torque Mode Functional Block Diagram

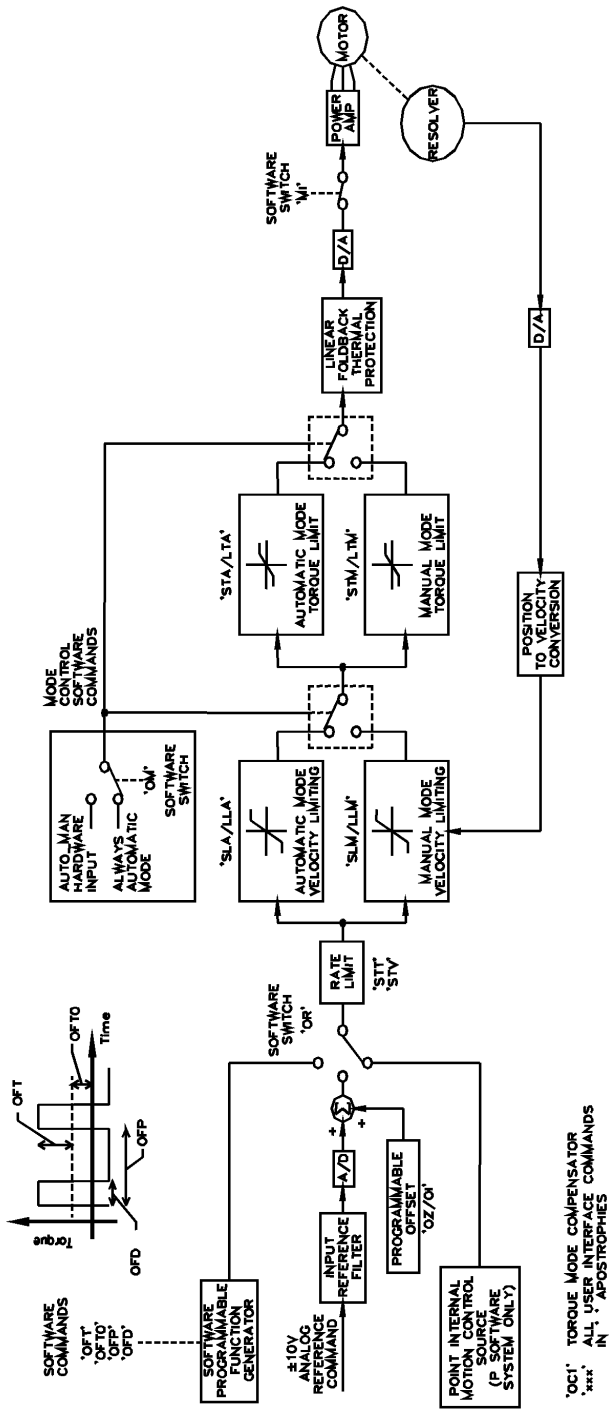

Figure 6.17:- T200 Torque Mode Block Diagram

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The diagram above outlines the operation of the T200 in torque mode. Note that Automatic/Manual mode is controlled by the Auto_Man digital input. However the switch-over between Automatic and Manual modes can be disabled by disabling the Manual Mode, leaving the T200 permanently in Automatic Mode (full power mode).

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6.7.2 Velocity Mode

In velocity mode the T200 closes a PI loop to track an analog command, a function generator command, a digital reference input command, or a velocity command from an internal position loop.

6.7.2.1 Velocity Mode Reference Sources

Five sources of velocity command may be user-programmed:-

1/ Internal Function Generator. The T200 provides an internal software function generator. The function generator produces rectangular pulses which provide a means of exciting the load, in order to diagnose applications problems or tune the T200. The Velocity Amplitude, Offset, Period of excitation and Duty Cycle are programmable. See Section 6.5 Internal Function Generator for further information.

2/ Analog Source:- The analog command input is limited to the range ±10V. A 10V command will tend to rotate the motor at the user-programmable **RPM_Per_10V** (RPM_per_10V defaults to the motor's Nominal Speed). The transfer function from voltage to velocity command is given by:-

$$\frac{V_{commnd}}{V_{in}} = \frac{\text{Nominal\_Speed}}{10V}$$

where Vin is the measured command voltage in volts, and $V_{command}$ is the commanded motor velocity.

3/ Point Motion Controller Source:- The T200's integral Point motion controller creates a velocity command as an output of loop closure function blocks. This function is available in the 'P' software version only.

4/ Digital Speed Reference Source:- The digital inputs PROG_SPD_0 and PROG_SPD_1 are used as indicators of the velocity at which the T200 should rotate. The operation of these inputs is described in Section 6.4.10 Programmable Speed Functions.

5/ CAN Velocity Mode:- As a subset of position mode operation, the T200 can be operated such that a digital velocity reference and a torque limit are transferred cyclically via the CAN interface, in Profile Mode. Operation of the CAN interface is described in Section 9.

6.7.2.2 Velocity Mode Offset Adjust

An automatic analog offset adjust mechanism exists for the analog velocity reference. This operates in exactly the same way as the offset-adjust in torque mode. See Section 6.7.1.2 Torque-Command Analog Offset Adjust.

6.7.2.3 Programmable Torque Limiting in Velocity Mode

The T200 uses the Automatic and Manual Torque Limits as described in Section 6.4.7 Automatic and Manual Power Settings, under the control of the AUTO_MAN digital input.

6.7.2.4 Programmable Velocity Limiting in Velocity Mode

The T200 applies the Automatic_Mode_Velocity_Limit and Manual_Mode_Velocity_Limits in velocity mode. The T200 will ensure that the actual velocity never exceeds the particular Velocity_Limit (which is selected from either the

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Automatic_Mode_Velocity_Limit or the Manual_Mode_Velocity_Limit depending upon the status of the AUTO_MAN input) by clamping the velocity command to the applicable Velocity Limit.

6.7.2.5 Rate Limiting in Velocity-Mode

The T200 provides a means of limiting the rate of change of the velocity command. This limits the acceleration (rate of change of velocity) which a sensitive load may experience during acceleration and deceleration phases of a motion.

The user can program the Velocity Rate Value (specified in RPM) and the Velocity Rate Time (specified in seconds). The maximum allowable rate of change of actual velocity is then given by:-

$$\overset{o}{V}command(MAX) = \frac{Velocity\_Rate\_Value}{Velocity\_Rate\_Time}$$

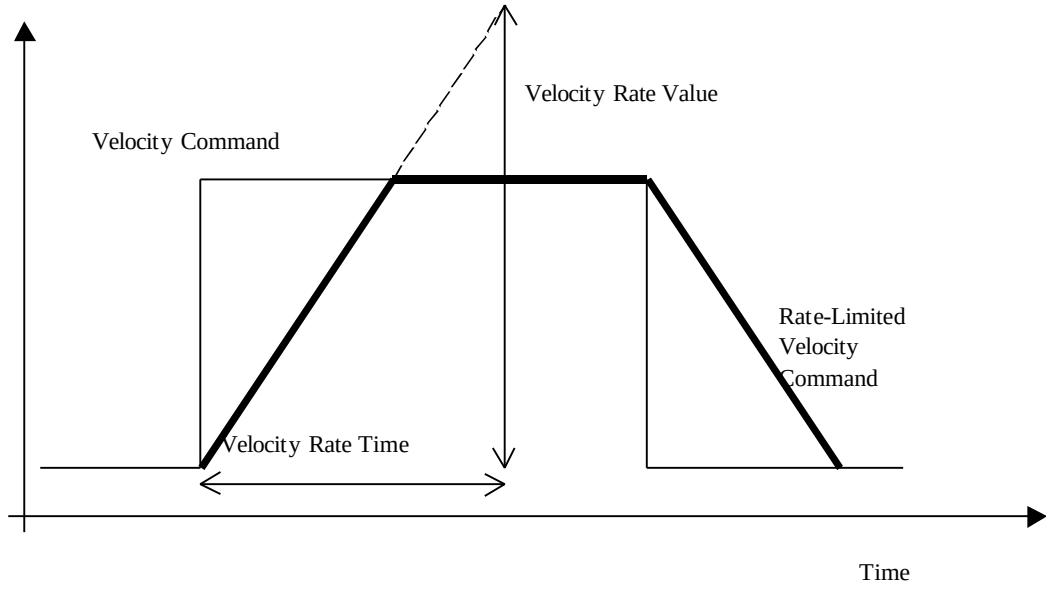

Figure 6.18:- Velocity Reference Rate Limiting

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6.7.2.6 Analog Torque Limiting in Velocity Mode

The Analog Torque Limit functions in exactly the same way in velocity mode, as it does in torque mode. See Section 6.7.1.6 Analog Torque Limiting in Torque Mode.

6.7.2.7 Velocity Mode Functional Block Diagram

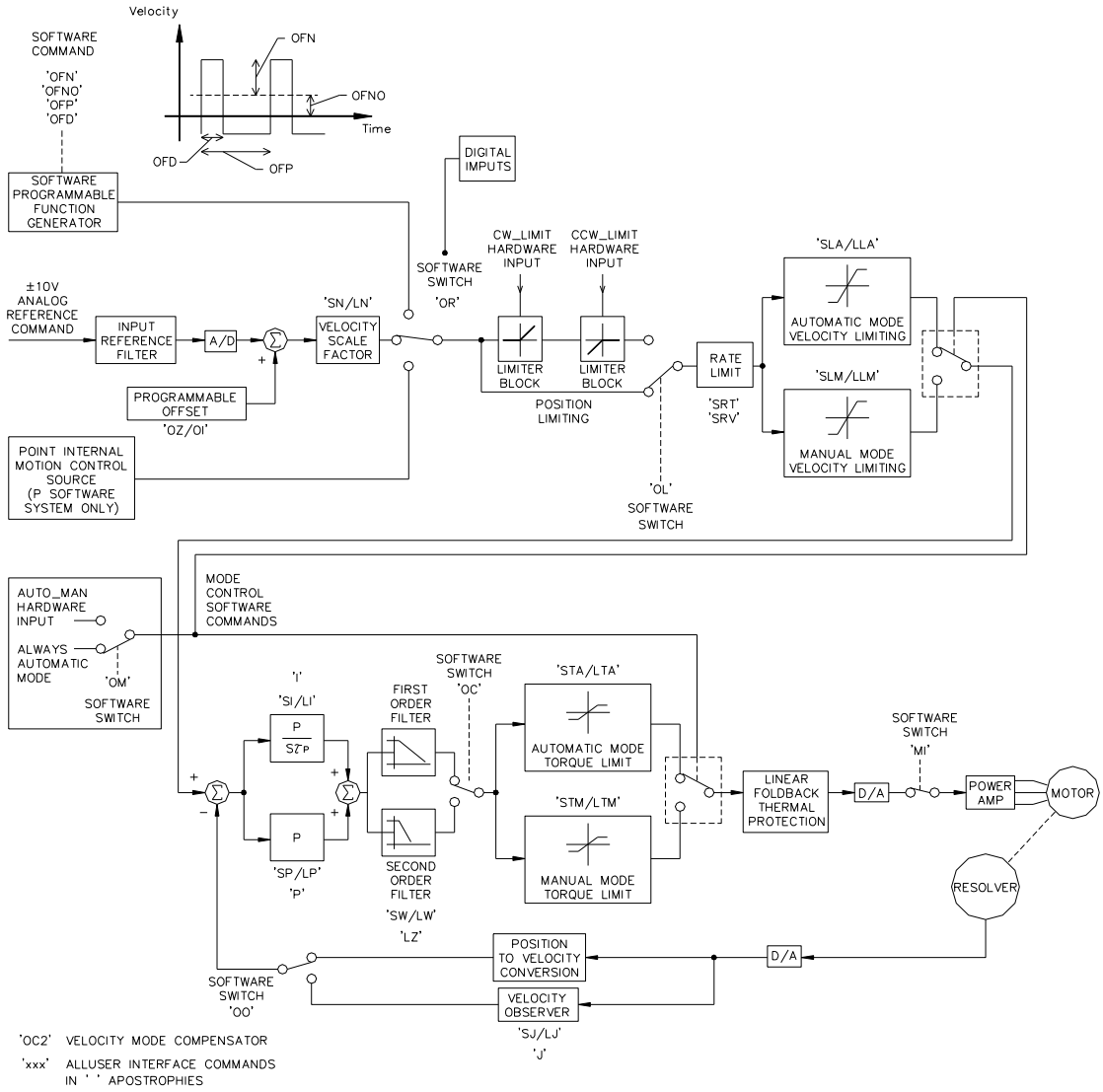

Figure 6.19:- Velocity Mode Block Diagram

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6.7.2.8 Velocity Loop Tuning

After completing drive initialisation (Motor Type selected, Options selected, etc.) the user should tune the velocity loop to optimise performance. This section provides a recommended velocity mode standard tuning procedure for use with either the WinDrive user interface or the Hand Held Terminal interface. The procedure should be followed in the sequence listed.

It is recommended that the drive is tuned using a low frequency square wave velocity command while observing the velocity response through the WinDrive Data Logger or an oscilloscope. The low frequency square wave can be supplied from an external source (through the **REF**erence analog input), or by the internal software Function Generator as described below.

CAUTION - Ensure that the application allows the use of this Speed Amplitude and length of travel, (period, duty cycle), without damage to the machine before proceeding with the tuning procedure.

Torque demand should be monitored through the IDC.CurrentMonitor variable in one of the two Data Logger Channels. This signal should not saturate during motor acceleration/deceleration (i.e. must be less than 10V or less than any torque limits which are applied). If the signal saturates then the Function Generator set up must be altered or the Servo-drive torque limit increased until saturation does not occur. The Actual Velocity variable should be monitored through the second Data Logger Channel. See Section 6.4.3 *TP1* Analog Output and 6.4.4 *TP2* Analog Output for a listing of the variables which can be displayed on the WinDrive datalogger or the analog Test Point TP1 and TP2.

NOTE - Actual Velocity and Torque Demand (IDC.CurrentMonitor) can also be sent to the TP1 and TP2 Test Points, through the Front Panel Test Points Dialog Box, and monitored with an oscilloscope. A description of how to set-up the WinDrive datalogger or the analog Test Points is given in Section 7 and Section 8.

The two principle parameters which affect the velocity loop dynamics are the Velocity Loop Proportional Gain (P) and the Integral Time Constant (I). The proportional gain term P acts on the measured velocity error, which is the difference between the requested velocity and the actual velocity. High P gain gives the system a faster response and tighter velocity control, but if the gain is set too high the system may become unstable. For best velocity tracking results the P gain should be set as high as possible without inducing severe overshoot or oscillation.

The Integral Time Constant I sets the gain for the integral term in the velocity error compensation. Integral gain is used to remove any steady state velocity error, due to system imperfections or due to disturbance torques from the load. Integral gain also provides disturbance rejection or 'stiffness' in the motor's reaction to an external torque load.

The following command description applies to the Hand Held Terminal. Similar commands for use with WinDrive when tuning are described in Section 7.

- The T200 will set the P and I terms to safe defaults when the T200 is configured with the appropriate motor.
- The P term is the first term to be adjusted. The I gain is effectively turned off by setting the Integral Time Const in the Tuning Dialog Box to a large value (e.g. 3 seconds).
- The Servo-drive should then be enabled; either the Hardware Enable should be applied using the ENABLE input, or the Software Enable can be used to conveniently control the drive power when the ENABLE is permanently active during the tuning process.

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- Use the **P** command set to enter the gain adjust mode for the velocity loop proportional gain term. Using the **PU** command increase the **P** gain until the shaft is turning. Use the P**U** command, while monitoring the velocity response on the oscilloscope, to increase the **P** gain until a slight overshoot occurs in the velocity response (Fig 1 below). Use the **PD** command to decrease the **P** gain until the overshoot just disappears (Fig 2 below) .

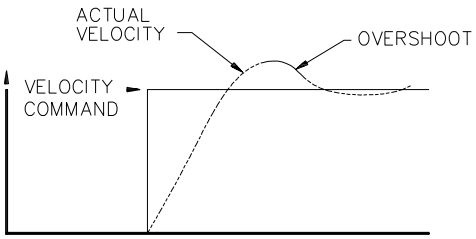

FIG 1.

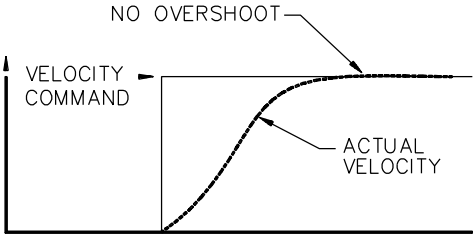

FIG 2.

- Use the **I** command set to enter the gain adjust mode for the velocity loop integral time constant. Using the **IU** command increase the loop response (this will actually reduce the Integral Time Constant) until a slight overshoot occurs again .

- Use the **P** command set to re-enter the P gain adjust mode. Use the **PU** command to improve the slope of the step response. Fig 3 illustrates the velocity wave form for a properly tuned loop.

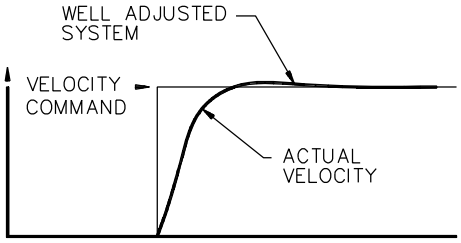

FIG 3.

6.7.2.9 Velocity Observer Tuning and Usage

This Section explains the set-up and tuning of the velocity observer. The use of the observer will usually allow significantly higher velocity loop gains and bandwidths to be achieved. The observer uses a software model of the motor and load to calculate a velocity estimate. The user needs to tune only one additional parameter to use the observer. The observer is set up using the following procedure:

- Tune the velocity loop using the normal procedure described in Section 6.6.2.8 . Figure 6.20 (A) below shows a typical tuned velocity loop response to a step reference command. It shows the torque response on the drives' TP1 test point and the actual velocity response on TP2. The size of the step velocity reference should be small enough to avoid saturation of the torque signal. Note the single overshoot of about 24% in the velocity response and the 12 ms settling time.

- Tune the observer by setting up the observer inertia parameter, Jest. Monitor the observer error signal θerr at the drives' TP1 test point (see Section 6.4.3 TP1 *Analog* Output and Section 8 for a description of the Hand Held terminal interface). Figure (B) shows the usual starting point for tuning: J_{est} is too small. Use the **JU** command to enter the gain adjust mode, (refer to Section 8 for an outline of hand held terminal commands). J_{est} may be adjusted in this mode using **JU** and/or J**D** commands, or using the **SJ** / **LJ** commands,(refer to Section 8). Figure

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(B) also shows θ_{err} when J_{est} is tuned correctly, θ_{err} steps with a slight ripple superimposed. θ_{err} is a measure of the model uncertainty, and of any disturbance torque which may be present. Normally there will be some viscous friction present, so that θ_{err} will step appropriately when the shaft velocity makes a step change.

CAUTION:-If θ_{err} oscillates excessively when the velocity makes a step change, as shown in Figure (C), then do not use the observer, since the load may not be modeled adequately by the observer.

- As a final check of proper tuning, display observer velocity on TP1, and compare it with the actual velocity response which was shown on TP2 in Figure (A). These should be identical.

- Switch on the observer by using the **OO** command, (reference Section 8), and then **Y** to the subsequent prompt to enable use of the observer velocity estimate. Figure (D) shows the velocity loop response when the observer is switched into the loop. Note the lack of overshoot, because of a better measurement of velocity. The servo noise generated is also reduced.

- In order to achieve higher gains, the compensator filter frequency may now be set higher, using the **SW** command, (refer to Section 8). Typically this frequency may be set to 600 Hz, depending on motor servo noise. The **P** and **I** gains may now be tuned up again, in the normal fashion described in 6.7.2.8 Velocity Loop Tuning. Figure (E) compares the response of an observer based system with a normal velocity loop system. Now the response settles in just 2.2 mS, whereas without the observer the step settled in about 12 mS. The observer response also shows a smaller overshoot.

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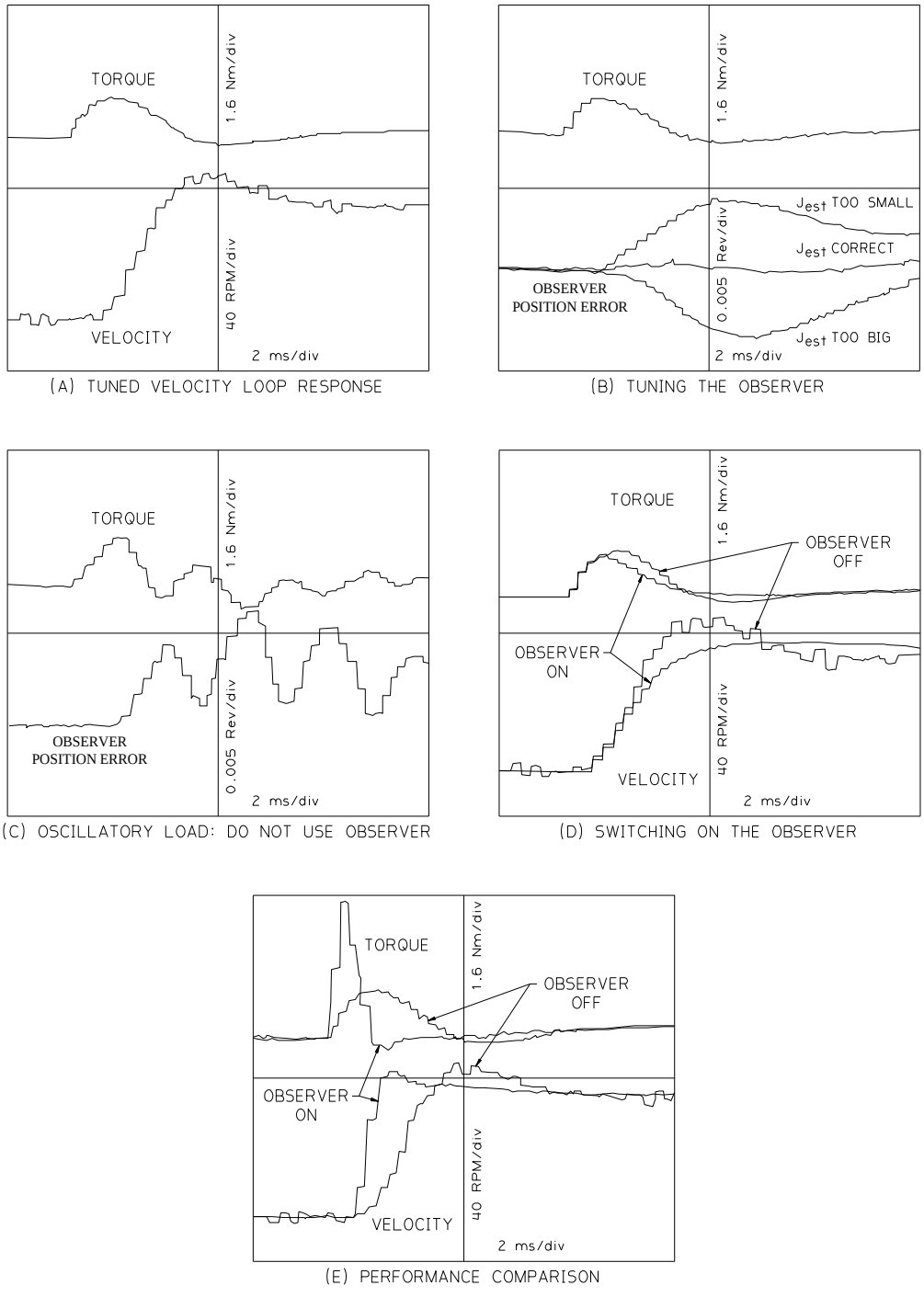

Figure 6.20:- T200 Observer Tuning

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6.7.2.10 Auto-tuning the Velocity Loop Gains and the Velocity Observer

The T200 auto-tuner can only be used in conjunction with the WinDrive interface. WinDrive contains proprietary algorithms which are used to stimulate motion in the load, using a excitation torque sequence, record the response of the load to the excitation, analyse that response to determine the load mechanical parameters, and set loop gains to achieve a user programmed velocity loop bandwidth.

CAUTION:- The auto-tuner places in T200 in velocity mode and excites the load using a torque excitation signal. If the axis under control is a vertical axis or an axis that counter-acts a torque load, then the axis may fall slightly when the auto-tuning sequence is started. The Auto-tuner is not suitable for use with such an axis, unless a slight drop of the vertical load or acceleration in one direction is acceptable to the user.

When the user selects the Auto Tune Button within the WinDrive Auto-tuning dialog, a pop-up dialog will be shown which informs the user that the T200 will be disabled, switched into velocity mode, re-enabled and a torque excitation signal will be applied. The user has the option to continue or exit from the sequence.

CAUTION - The drive is enabled when Auto Tuning is in progress, high frequency excitation signals are applied to the motor. The user should ensure that the mechanical coupling and load are capable of withstanding a high frequency torque content. If in doubt, the magnitude of the torque excitation should be dropped to about 10% of peak. The user can then slowly increase the magnitude of the excitation torque if the response is not sufficient to identify the system.

NOTE:- The auto-tuner software will try to enable and disable the T200 high power stage, as well as control the brake. For the T200 to actually enable the high power, and release the brake, the user must have the following done BEFORE the auto-tuning is started:-

1. **Ensure that the enable digital input (ENABLE) is activated** (see Section 3.15.5). High power cannot be applied to the motor if this input is not activated.
2. **Ensure that the brake control input (BRK_IP) is activated** (see Section 3.15.5). The motor brake cannot be released unless this input is activated.

If the user chooses to Continue:

1. The T200 will be disabled automatically via software.
2. The T200 will switch into Velocity Mode
3. The high power amplifier will be enabled by software automatically
4. The motor brake, if present, will be released
5. The excitation signal will be generated by the GUI, using the user defined excitation signal amplitude.
6. The excitation signal will be downloaded to the T200
7. The excitation signal will be applied by the T200 via the motor to the load.
8. The Actual Position and the excitation Signal are data-logged, and uploaded to the WinDrive interface.
9. The motor brake, if present, is re-applied.
10. The T200 will be disabled.
11. System Identification is performed by WinDrive to determine the physical attributes of the motor/load combination.

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A Systems Parameters dialog box is then displayed showing the results of the System Identification. The user must choose to calculate gains, and then exit the system parameters dialog.

When the user exits the system parameters dialog a pop-up dialog will be shown which informs the user that the calculated gains will be downloaded to the T200, T200 will be switched into velocity mode, and a step response will be obtained. The user has the option to continue or exit from the sequence.

If the user chooses to Continue:-

1. The calculated gains will be downloaded to the T200.
2. The determined inertia will be used to set-up the observer inertia of the T200.
3. The T200 will be switched into velocity mode.
4. The internal function generator will be set-up with a 200 RPM reference for the motor.
5. The T200 will be enabled, and will rotate less than one motor shaft revolution.
6. The Actual Velocity and the Torque Reference are datalogged, and uploaded to the GUI
7. The T200 will be disabled.

The System Identification can determine two possible motor/load characteristics:-

1. Lumped Inertia
2. Simple Resonant System (with a single resonance)

Higher order and more complex loads will cause the Identification Algorithm to prompt the user to tune the T200 manually.

NOTE:- If a Type 1 Load was found (non-resonant) after a successful Auto-Tuning sequence, the user can enable the Velocity Observer, without further tuning of the observer.

NOTE on Incorrect Detection of Resonant Systems:- If motor movements are small during the auto-tuning excitation, because of a large load inertia, or the environment is electrically noisy, the auto-tuning algorithm may detect a resonant load even though the coupling between the motor and the load is extremely stiff. The user should run the algorithm again to verify that the load is resonant. If the algorithm detects a Type 1 Load (lumped inertia load) the second time the auto-tuner is run, then that identification is likely to be correct, and the user can use the gain values suggested by the auto-tuner.

6.7.2.11 Monitoring the Velocity Tracking

The T200 will warn a user if the actual velocity is not tracking the velocity command, by indication on the seven segment display. If the velocity error (difference between the velocity command and the actual velocity) is greater in absolute terms than the Warning_Velocity for at least the Warning_Velocity_Time, then the seven segment display will flash the warning. This can be useful when tuning a T200 initially in an application, as well as for ongoing monitoring. Once the application is properly configured, the Warning_Velocity and the Warning_Velocity_Time can be reduced so that if machine wear or other damage occurs, which causes excessive torque to track a command, the T200 will indicate the difficulty in tracking the commanded velocity.

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6.7.3 Position Mode

6.7.3.1 Position Mode Reference Sources

One of the following sources for position command need to be programmed by the user:-

1/ Internal Function Generator. The T200 provides an internal software function generator for position reference generation. The function generator produces spline shaped position profiles, in order to tune the T200. Position loop gains. The Acceleration, Traverse, Velocity Amplitude, Offset, Period of excitation and Duty Cycle are programmable. See Section 6.5 Internal Function Generator for further information.

2/ Analog Source:- The analog command input is limited to the range ±10V. The transfer function from voltage to position command is given by:-

$$\frac{\Theta_{command}}{V_{in}} = \frac{\text{Revs\_Per\_10V}}{10V}$$

where V_{in} is the input voltage

Revs_per_10V is a user-programmed scaling factor

$\Theta_{command}$ is the commanded motor position

3/ Point Motion Controller Source:- The T200's integral Point motion controller creates a position command as an output of loop closure function blocks. This function is available in the 'P' software version only.

4/ CAN Source:- The T200 can be operated in fine-interpolation positioning mode or point-to-point positioning profile mode. See Section 9.

5/ Stepper Motor Interface Mode:- The T200 can use its RS422 type incremental encoder input as a means of inputting stepper mode Up/Down, and Quadrature mode inputs. See Stepper Motor Interface.

6.7.3.2 Position Mode Offset Adjust

An automatic analog offset adjust mechanism exists for the analog position reference. This operates in exactly the same way as the offset-adjust in torque mode. See Section 6.7.1.2 Torque-Command Analog Offset Adjust for a description.

6.7.3.3 Programmable Torque Limiting in Position Mode

The T200 uses the Automatic and Manual Torque Limits as described in Section Automatic and Manual Power Settings, under the control of the AUTO_MAN digital input.

6.7.3.4 Programmable Velocity Limiting in Position Mode

The T200 applies the Automatic_Mode_Velocity_Limit and Manual_Mode_Velocity_Limits in position mode. The T200 will ensure that the actual velocity never exceeds the particular Velocity_Limit (which is selected from either the Automatic_Mode_Velocity_Limit or the Manual_Mode_Velocity_Limit depending upon the status of the AUTO_MAN input) by clamping the velocity command, which is output from the internal position control loop, to the applicable Velocity Limit.

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6.7.3.5 Analog Torque Limiting in Position Mode

The Analog Torque Limit functions in exactly the same way in position mode, as it does in torque mode. See Section 6.7.1.6 Analog Torque Limiting in Torque Mode for a full description.

6.7.3.6 Position Limits in Position Mode

There are two means of activation of position limiting in the T200, when it operates in position mode.

1. **Hardware Limit Switches**:- Hardware Limits Switches are described in Section 6.4.5 - Limit Switch Function. The reaction of the T200 in various modes of operation are described in that section.
2. **Software Position Limits**:- CAN Profile and Interpolation modes, as well as the Point Motion Control system, provide software limit switch functionality. See the Point Manual for the Point software position limits. (This function is not provided in Stepper Motor Interface mode as the hardware limit switches are already active and there is no Homing Cycle in that mode.)

6.7.3.7 Velocity Rate Limiting in Position Mode

The Velocity Command (as the output of the position loop section) may be limited in exactly the same fashion as in velocity mode (see Section 6.6.2.5 Rate Limiting in Velocity-Mode).

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6.7.3.8 Position Mode Functional Block Diagram

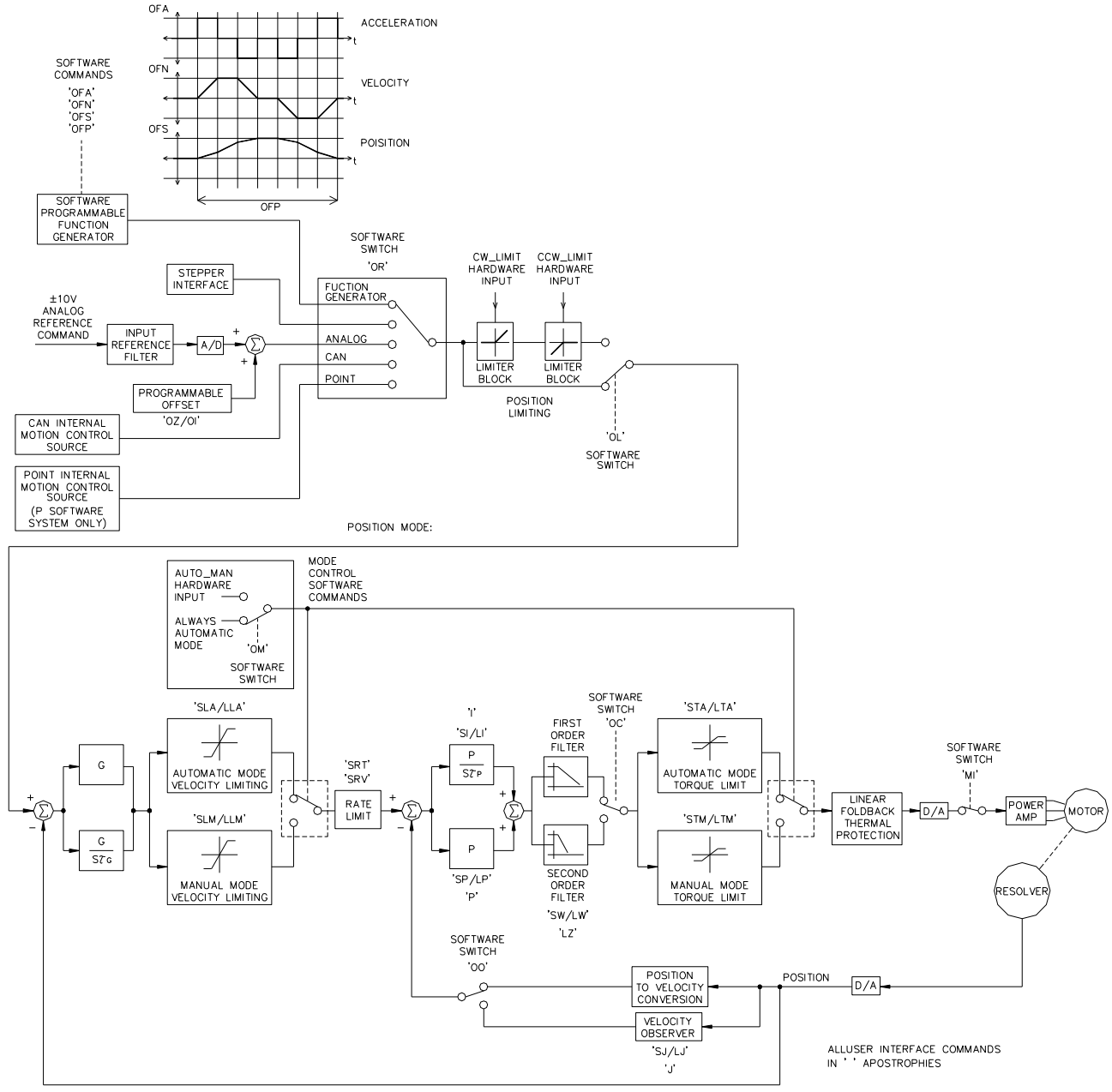

Figure 6.21:- Position Mode Block Diagram

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6.7.3.9 Position Loop Tuning

Before tuning the position loop, the user should first tune the velocity loop as described in Section 6.6.2 Velocity Mode. This makes the process of tuning the position loop easier, because the inner velocity loop has already been increased to as high a bandwidth as the application will allow. Such a velocity loop tuning should make the position loop tuning seem to be as easy as tuning a first order system. This section provides a recommended position loop standard tuning procedure. The process applies to use of the Hand Held Terminal. However the user should follow a parallel process using the WinDrive interface. The procedure should be followed in the sequence listed. The appropriate user manual should be consulted for appropriate user interface commands.

- Disable the Servo-drive, using the ENABLE digital input.
- Set the *Control Compensator* to *Position Mode*.
- The position loop is tuned using a low frequency square wave position command while observing the velocity response on an oscilloscope. This low frequency square wave position command can be supplied from the internal *Position Mode* software function generator as described below.
- Set up the position loop function generator to produce a high acceleration trapezoidal velocity profile as follows:

  - Traverse to 5 revolutions.
  - Speed Amplitude to 10% of rated motor speed.*
  - Acceleration to maximum allowed value. (Note machine restrictions)
  - Period to 10 seconds.

* Tuning speed should be set low enough to avoid saturation of the torque demand. Torque demand can be monitored by directing the IDC_Current Monitor signal to one of the TP1 and TP2 analog output channels, and monitoring signal this with an oscilloscope. This signal must not saturate during motor acceleration/deceleration (ie. must be less than 10V). If the signal saturates then the function generator set up must be relaxed until saturation does not occur, by reducing the Acceleration or the Speed_Amplitude parameter.

CAUTION:- *Ensure that the application allows using this speed amplitude and length of travel, (period, duty cycle), without damage to the machine before proceeding with the tuning procedure.*

To monitor actual Velocity, connect an oscilloscope to an analog O/P channel test point with the following settings:

Horizontal Amp: 20 mS/Division
Vertical Amp: 1 V/Division

Direct the velocity feedback signal to TP1 (See Section 8 for a description of the Hand Held Terminal commands).

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Tuning the Position loop.
The following technique should be used to tune the position loop using the set-up loop described earlier.

- Enable the Servo-drive; *Hardware Enable* first using the external enable I/P, then *Software Enable*, with the function generator initialised as detailed above.

- Use the G**U** command, while monitoring the velocity response on the oscilloscope, to increase the **G** gain (position Loop Proportional Gain) until a slight overshoot occurs in the velocity response Fig 4. Use the G**D** command to decrease the **G** gain until the overshoot just disappears (Fig 5).

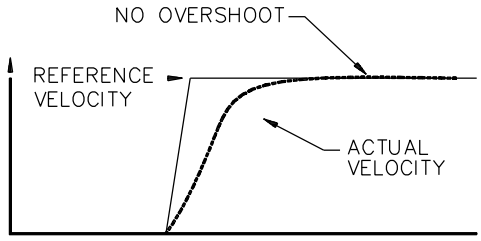

FIG 5.

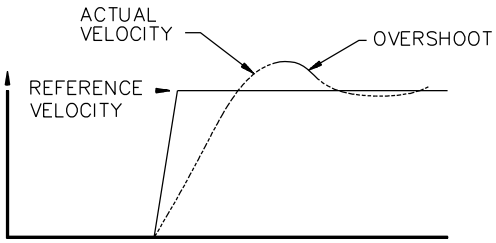

FIG 4.

NOTE:- If the autotuner has already been used successfully, then the user can try a value of Bandwidth * 2.0 for the Position Loop Gain parameter (**G**). This should be a good first estimate for the position gain.

6.7.3.10 Monitoring the Velocity Tracking in Position Mode

The T200 provides the same velocity monitoring in position mode as it does in velocity mode. See Section 6.7.2.11 Monitoring the Velocity Tracking, for a full description.

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6.7.3.11 Monitoring the Position Tracking in CAN Interpolation Mode

The T200 also provides monitoring of the position error in CAN Interpolation mode. Two parameters are provided for the user to configure this tracking. These are:-

- **Static Loop Position Error Band**:- This quantity is specified in position increments (see Section 7.10.1.3 CAN Position Scaling for an explanation of the scaling). It is the maximum allowed position error that the user can allow when the drive is not moving or moves at a very low velocity. The Static Loop Position Error Band can be programmed using the STS Hand Held terminal command.
- **Dynamic Loop Position Error** is the ratio of the slopes of the two lines shown in the Figure 6.22 below. A position system that has no velocity feed-forward term will have a position error that is proportional to the actual velocity. The Dynamic Loop Position Error in effect implies how many times greater a position error than this expected position error, the user will tolerate in his application. Note that this parameter can be set to a value less than 100%, for a system which uses velocity feed-forward terms (CAN systems use feed-forward terms, to reduce the position loop error).

The warning condition will be indicated on the T200's seven-segment display, if the position error exceeds the Position Error Allowed (see diagram below).

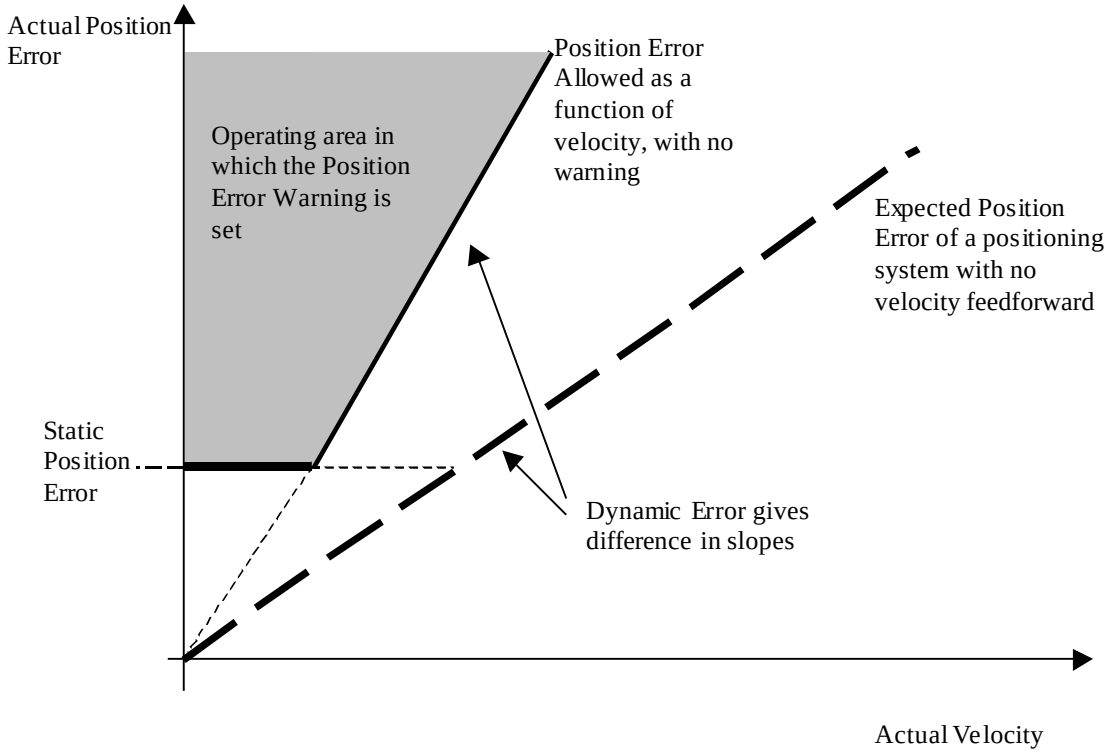
Actual Position Error
Position Error Allowed as a function of velocity, with no warning
Operating area in which the Position Error Warning is set
Expected Position Error of a positioning system with no velocity feedforward
Static Position Error
Dynamic Error gives difference in slopes
Actual Velocity

Figure 6.22:- Position Error Monitoring

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6.8 Fault Detection

6.8.1 Faults and User Indication in the T200

This sections outlines faults which are detected in the T200

6.8.1.1 Faults and Warnings

The T200 distinguishes between faults and warnings. Faults are those abnormal conditions that are of a serious enough consequence to cause the T200 to halt operation. This will always result in removal of power from the T200 high power amplifier, and will usually result in application of a motor brake, if present, with CAN and Point modes of functionality.

Warnings are those abnormal conditions that do not in themselves yet constitute a peril to the equipment or to personnel.

6.8.1.2 Fatal Faults and Non-Fatal Faults

The T200 distinguishes between two types of faults:-

- **Fatal Faults** are those faults with which the T200 cannot continue to control the motor. The T200's reaction to a fatal fault is to immediately disable the switching of the power amplifier. For example, if resolver position sensing is lost, the motor cannot be commutated. The ability to control the motor output torque is therefore lost and the T200 immediately disables high power from the motor.
- **Non-Fatal Faults** are those faults which will likely lead to equipment failure or hazards to personnel, but the T200 is still capable of controlling the motor output torque. For example, a loss of CAN communication is treated as a non-fatal fault, because the T200 can control a servo-stop of the motor. Non-Fatal faults lead to servo-stops of the motor at the Emergency Deceleration Rate, and then the T200 high power amplifier is disabled.

Individual Fatal and Non-Fatal faults are described and categorised below.

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6.8.1.3 Fatal Faults

The following is an overview of the fault detection mechanisms in the T200. Note that the fault codes that are displayed on the 7-segment display are explained in Section 3.19.

Power Amplifier Short Circuit [F 1]

A power amplifier short circuit fault occurs when a short circuit between any one of the motor phases or between a motor output phase and DC+ or DC- causes a fault current to flow. The Short Circuit detection circuitry detects such a fault current and disables the T200 output inverter power amplifier. When the power amplifier is disabled the fault current will cease but the fault remains latched until it is cleared by re-enabling the T200.

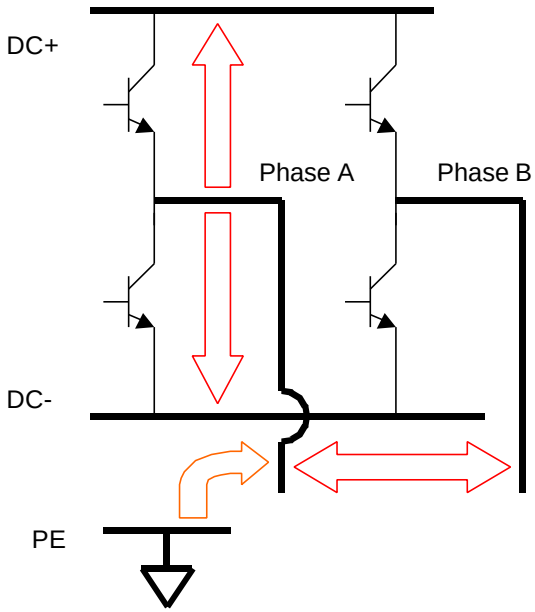

Figure 6.23:- Detectable Short Circuit Faults

If a Power amplifier Short Circuit fault occurs the system should be checked to determine the source of the short circuit. The problem should be rectified before attempting to re-start the drive.

Bus-Overvoltage Fault [F 2]

A bus-over-voltage fault occurs when the high voltage D.C. Bus that supplies power to the inverter power amplifier exceeds a pre-set high level. This level is primarily determined by the voltage rating of the components which sit on the D.C. Bus. Bus-over-voltage faults generally occur due to dynamic braking of the servo motors. When brushless DC servo motors are braking they supply power back to the D.C. Bus that supplies the output inverter. This causes the DC reservoir capacitors on the D.C. Bus to charge up. A regeneration circuit normally dumps this energy in resistive loads when the voltage on the D.C. Bus capacitors reaches set levels. However if the energy being produced by the braking load exceeded the capability of the regeneration circuitry, or if this regeneration circuitry has malfunctioned, the D.C. Bus continues to rise until D.C. Bus over-voltage levels are reached. When a D.C. Bus overvoltage fault is detected the output inverter power amplifier is disabled. The fault remains latched until it is cleared by re-enabling the drive.

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Note:- the T200 provides a measurement of the Regeneration Continuous Power over the last averaging period. The '?LRR' Hand Held terminal command will display the average energy which has been expended over that period. This will help in sizing the regeneration resistance needed. This power measurement is accurate to ±10% of the actual regeneration power being expended.

If WinDrive is used the calculated average regen energy can be displayed via the parameter EXTREGEN.ACTUALPOWER within the EUI dialog box.

NOTE:- If a D.C. Bus overvoltage fault occurs check that the regeneration circuit is suitable for the application. Consult Moog for further details.

Resolver Fault [F 8]

Moog Servo drive systems utilise resolver-based motor-shaft-position feedback. The resolver is an integral part of the servo-motor and is connected to the servo-drive via a dedicated resolver cable. The T200 has built in resolver checking algorithm that continually monitors the resolver inputs and checks for cable breaks. If resolver signals are not present then the drive disables and the fault is latched.

CAUTION:- If this fault occurs check that the resolver cable is plugged in correctly at both the motor and the Servo-drive. If this does not solve the problem check that the cable is intact. If fault persists consult Moog.

Analog Power Supply Fault [F 9]

This fault occurs in the event of the internal analog-control power-supply voltages falling below pre-set levels. This can happen if the power supplies are overloaded. If this fault occurs then the drive is disabled and the fault is latched.

CAUTION:- If this fault occurs check that adequate voltage levels exist on the backup power supply (24V and isolated 120Va.c.). If fault persists consult Moog.

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6.8.1.4 Non Fatal Faults

The following is an overview of the non-fault detection mechanisms in the T200. The fault codes that are displayed on the 7-segment display are explained in Section 3.19.

A.C. Mains not applied or **High Power Not Ready Fault [U 1]**

- **A.C. Mains not applied**
  This condition is treated as a Non Fatal Fault because most motion control system will power-on logic level power, and carry-out self-configuration and self-diagnostics before application of a.c. mains power. If the Non Fatal Fault does occur, it should be interpreted differently for each type of T200 (with and without integral high power PSU). If the drive model is T200-X10 then no a.c. mains is present. If the drive model is a T200-X00, then the Power-Ready signal from the T200-X10 is not beeing received, I.e. the DC-bus is not present. If this fault occures the drive decelerate and disables.

- **High Power Not Ready Fault**
  The T200 Servo-drive has a soft start feature that limits the inrush current from the a.c. mains. While the Servo-drive is in soft start mode then the High Power Not Ready fault is reported and the T200 cannot be enabled. When the soft start is over then this fault is cleared and the output inverter power amplifier can be enabled. This circumstance is brought to the attention of the user because if it occurs during normal operation, the drive will decelerate and disable.

CAUTION:- If A.C. mains is applied and this fault occurs do not attempt to restart the drive. Consult Moog for further instructions.

CAN Communications Loss [U 7] or Programming Error [U 9]

The T200 monitors the reception of messages expected on CAN and also checks that it could successfully transmit messages as required. This fault indicates that the drive cannot establish or has lost reliable communications via CAN with its Host controller. Also if the T200 is in CAN Profile mode, and an unachievable command is sent to the T200 via the CAN interface (e.g. too high speed movement), the T200 will indicate the fault, decelerate and disable.

Quick Stop Active [U A]

Indicates that the Quick Stop digital input is active. The drive will decelerate and disable when this input is active.

Incremental Encoder or Stepper Motor Input Loss [U b]

This fault is only active when the drive is configured for a Stepper Motor Reference, or the Point system uses the incremental encoder, and the appropriate signals are not present. In this case the drive will not disable, but will simply hold its present position.

Regen Fuse Blown [F 3]

A regeneration fuse blown fault occurs when the protection fuse for the internal regeneration circuitry blows. This can happen by excessive switch on/off cycles of the a.c. mains (see Section 3.10) or if the internal regeneration circuit power transistor fails. When a regeneration fuse blown fault occurs, the drive decelerates and disables and the fault is latched.

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If the drive is powered down after the internal regeneration fuse has blown and then powered up again, the high voltage D.C. Bus will not charge up and the T200 will report that all PSU related faults have occurred.

CAUTION:- If a regeneration fuse blown fault occurs, the user should not attempt to restart the drive. Consult Moog for further details.

A.C. Mains PSU Temperature Fault [F 4]

A PSU temperature fault occurs if the PSU main rectifier heatsink exceeds a pre-determined level. This can occur if the cooling fan(s) fail or the airflow is restricted. When this fault occurs then the drive decelerates and disables and the fault is latched.

CAUTION:- If this fault occurs then the operation of the cooling fan(s) and airflow restrictions should be checked. If the fault still occurs then consult Moog for further details.

Power Amplifier Temperature Fault [F 5]

A power amplifier temperature fault occurs if the power inverter heatsink temperature exceeds a pre-determined level. This fault should not occur if the Servo-drive is operated within its environmental specifications due to the operation of thermal foldback self-protection algorithms. However the fault can occur if the cooling fan(s) fail or the airflow is restricted. When this fault occurs then the drive decelerates and disables and the fault is latched.

CAUTION:- If this fault occurs then the operation of the cooling fan(s) and airflow restrictions should be checked. If the fault still occurs then consult Moog for further instructions.

Motor Temperature Fault [F 6]

A motor temperature fault occurs if the temperature of the motor windings exceeds 155°C. This can occur if the motor is operated outside its maximum continuous ratings or if the motor does not have adequate heatsinking. When this fault occurs the drive is disabled and the fault is latched.

CAUTION:- If this fault occurs then motor operation and motor mounting/cooling should be checked. If the fault still occurs then consult Moog for further instructions.

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6.8.1.5 T200 Warnings

The following is an overview of the warnings detection mechanisms in the T200. Note that the warning codes that are displayed on the 7-segment display are explained in Section 3.19.

Thermal Foldback Active [.]

This warning is active when the torque command is limited due to thermal current limiting (See Self Protection). In this case the user may interrogate using either WinDrive or the Hand Held Terminal to check the present thermal limit.

Motor Thermal Warning [U 2]

This warning indicates that the motor winding temperature has exceeded 130°C.

Power Amplifier Thermal Warning [U 3]

This warning indicates that the power transistor heatsink temperature has exceeded an appropriate temperature.

Position Tracking Error [U 4]

This warning indicates that the position error has exceeded a user-set threshold. This error will only be present when the drive is in position mode.

Velocity Tracking Error [U 5]

This warning indicates that the velocity error has exceeded a user-set threshold. This error will be checked in all position and velocity modes.

Regeneration Limit Exceeded [U6]

The T200 monitors the status of the external regeneration resistor duty cycle, in order to determine if the resistor's continuous thermal rating is being exceeded. If it is then the T200 will issue a warning. See Section 3.13 for specifications of the regeneration resistors for each particular T200 model.

Limit Switch(es) Asserted [U 8]

Indicates whether the clockwise and counter-clockwise digital inputs are active. If in Velocity mode, if the limits are enabled the motor will not rotate in the direction for which the input was activated. For example if the clockwise digital input is in-active there will be no motion in that direction. Note that if the limit switches are disabled, then the warning U8 will not flash even if the limit switch hardware is activated.

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6.8.2 Fault History Record

The T200 records all faults and warnings as these occur in a special non-volatile memory. Approximately every 0.5seconds the T200 checks have any new faults been reported. The time stamp is relative to the time the drive is powered.

The T200 has sufficient space to record 1024 such faults or warnings, so that it should be able to continue recording such fault and warning data for a significant number of fault occurrences. No way of erasing this data is provided.

To avoid filling up memory space with irrelevent data, recorded data are separated in two categories, Faults and Warnings.

Faults will be latched and need to be reset with a positive transition of the enable signal. Only the first occurence of a fault after it is reset will be recorded. Faults are recorded in both Enabled and Disabled Drive state.

Warnings will only be recorded at their first occurence if the T200 is enabled. This avoids repetitive recording of e.g. position following errors.

Faults and warnings are described in section 10, Trouble-Shooting Guide.

The WinDrive interface provides a means of uploading the fault data and printing this to an ASCII file with a user record of the application. See Section 7.9.6 for further details.

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6.8.3 Fault indication via digital outputs

To allow drive status and fault diagnostics with a PLC drive status and fault information is available on the digital outputs of the T200.

Fault indication via digital outputs is only available if the drive operates in the following modes:

- Velocity mode with analog reference.
- Torque Mode with analog reference.
- Digital Speed Input
- Stepper Mode (only Mode 1 available)

6.8.3.1 Mode 1: Fault indication via digital outputs disabled.

This mode allows a limited fault indication as only two digital outputs can be used.

Digital / Relay Outputs (functionality dependent on control mode)					
Digital Output	**Current/Velocity Mode (±10V Reference, Digital Speed Input)**	**Position Mode (Custom POINT, for Simple Point see spec)**	**Position Mode CAN Profile-Mode**	**Position Mode CAN Inter-polation Mode**	**Stepper Mode**
DO1 (J1/19)	Limit Active	Limit Active	Limit Active	Limit Active	Limit Active
DO2 (J1/20)	Drive Enabled	Drive Enabled	Drive Enabled	Drive Enabled	Drive Enabled
DO3 (J1/21)	Speed/Torque achieved	User defined	Speed/Torque achieved	User defined	Following Error exceeded
DO4 (J1/27)	Fault Code Bit 1	User defined	Undefined	User defined	Fault Code Bit 1
DO5 (J1/28)	Fault Code Bit 2	User defined	Undefined	User defined	Fault Code Bit 2
Relay (J1/22, J1/23)	System Ready (relay output)	System Ready (relay output)	System Ready (relay output)	System Ready (relay output)	System Ready (relay output

Table 6.3 Digital/Relay Outputs (Mode 1)

Digital outputs four and five indicate the following drive status.

Dig. Output DO5 (Fault Code Bit 2)	**Dig. Output DO4** (Fault Code Bit 1)	**Status of the drive**
0	0	Drive ok. No faults
0	1	Motor Fault
1	0	Amplifier Fault
1	1	Limit Switch Active

Table 6.4 Status Indication via DO4 and DO5 (Mode 1)

Note:
0 means a logical 0. I.e. no current flowing.
1 means a logical 1. I.e. current flowing.

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Drive Status in Mode 1 has the following meaning:

1. Drive ok

This status indicates that the drive has no faults. The status is independent of AC-mains. I.e. “Drive ok” will be indicated even when AC-mains is not applied. PSU faults, which can only be evaluated when AC-mains is applied, will be indicated.

2. Amplifier Fault

This fault is enabled when one or more of the following faults are active:

- Bridge Overcurrent
- Bus Overvoltage
- Regen Fuse Blown
- PSU Overtemperature
- Bridge Overtemperature
- ±15V Fault
- Encoder Input Missing

3. Motor Fault

This fault is enabled when one or more of the following faults are active:

- Motor Temperature Fault
- Resolver Fault

4. Limit Switch Active

This status information indicates that one of the two Limit Switches (CW or CCW) is active.

6.8.3.2 Mode 2: Fault indication via digital outputs enabled

This mode makes use of four digital outputs to indicate the drive status to the PLC. The meaning of digital outputs one and three is redefined as described in Table 6.5. As indicated in the table this is only valid if the drive is not using Point or CAN as a reference source.

Digital / Relay Outputs (functionality dependent on control mode)					
Digital Output	**Current/Velocity Mode (±10V Reference, Digital Speed Input)**	**Position Mode (Custom POINT, for Simple Point see spec)**	**Position Mode CAN Profile-Mode**	**Position Mode CAN Inter-polation Mode**	**Stepper Mode (Fault indica-tion Mode 1; Mode 2 not sup-ported!)**
DO1 (J1/19)	Fault Code Bit 1	Limit Active	Limit Active	Limit Active	Limit Active
DO2 (J1/20)	Drive Enabled	Drive Enabled	Drive Enabled	Drive Enabled	Drive Enabled
DO3 (J1/21)	Fault Code Bit 2	User defined	Speed/Torque achieved	User defined	Following Error exceeded
DO4 (J1/27)	Fault Code Bit 3	User defined	Undefined	User defined	Fault Code Bit 1
DO5 (J1/28)	Fault Code Bit 4	User defined	Undefined	User defined	Fault Code Bit 2
Relay (J1/22, J1/23)	System Ready (relay output)	System Ready (relay output)	System Ready (relay output)	System Ready (relay output)	System Ready (relay output

Table 6.5 *Digital/Relay Outputs (Mode 2)*

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The dedicated digital outputs indicate the drive status as follows.

Drive Status	Indication	DO1,DO3...DO5 (DO1=LSB)
FAULTS AND STATUS		
Drive OK. No Faults.	O	0000
Foldback	[.]	0001
Bridge Overcurrent	F1	0010
Bus Overvoltage	F2	0011
Regen Fuse Blown	F3	0100
PSU Temperature Fault	F4	0101
Bridge Temperature Fault	F5	0110
Motor Temperature Fault	F6	0111
Programming Error	F7	1000
Resolver Fault	F8	1001
±15V Fault	F9	1010
WARNINGS		
Bus Not Active	U1	1011
Regen Exceeded	U6	1100
Limit Switch Activated	U8	1101
Inc. Encoder	Ub	1110
Warning Temperature	U2 | U3	1111

Table 6.6 Status Indication (Mode 2)

See Section 10 for a description of the meaning of the faults.

"Warning Temperature" is a logical or of "Motor Warning Temperature" and "Bridge Warning Temperature".

If more than one fault or if more than one warning is present the time period a warning/fault is indicated is one second. I.e. the first fault/warning will be displayed for 1s then the second one will be displayed for 1s and so on.

The selection between the two modes can be done via the WinDrive EUI interface or via a POD command as described in section 8.

The command to set the drive in one of the above mentioned modes is **"SFI"**. The command to read the currently active mode is **"LFI".**

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6.9 Self Protection

6.9.1 Sources of Torque Limits

There are three sources of torque limitation within the T200:-

1. **Programmable Torque Limits**:- The user may program Automatic_Mode and Manual _Mode Torque_Limits. These are described in Section Automatic and Manual Power Settings.
2. **Analog Torque Limit**:- The Spare Analog Input is used as a means of reading in a analog torque limit command. This is described in Section 6.6.3 Position Mode.
3. **Thermal Torque Limits**:- The T200 provides a comprehensive thermal protection of the motor, the power electronics and cabling and interconnect. These are described below in greater detail.

The minimum of these sources at any time is used to limit the available current. Note however that the Limit_Active digital output function will only activate when the current demand is greater than a ***Thermal-Limit***. This is because the other limits are set by the user anyway.

6.9.2 Power Amplifier Thermal Protection Mechanism

The power amplifier is protected by using a scheme called Thermal-Foldback. The T200 is rated to operate at an ambient temperature of up to 55°C.

- The Foldback scheme is designed to ensure a very conservative temperature margin is maintained between power device manufacturer's rated maximum temperatures (semiconductor junction temperature) and the actual semiconductor junction temperature.
- The Running Thermal Limit applies when the speed of the motor is greater than approximately 50RPM. The Stall Thermal Limit applies for motor shaft speeds of less than approximately 50RPM. The Stall Limit will become less than the peak current capability of the amplifier only at elevated ambient temperatures and high continuous operating loads.

6.9.3 Motor Protection Thermal Protection Mechanism

- The T200 measures the temperature of the motor by means of measurement of the Negative Temperature Coefficient thermistor buried within the motor windings. The motor temperature is measurable between approximately 25°C and 175°C.
- Software calculates the motor thermal limit based upon the motor windings temperature. The motor protection scheme is intended to ensure that the temperature of the motor core will not exceed 155°C.

6.9.4 Cabling and Interconnect Protection Scheme

Each T200 model has a continuous current rating. The T200 operates an algorithm that limits the overall RMS level of motor phase current appropriately, over a time window that extends over the last averaging period. This is intended to protect the connectors and internal circuitry, which would otherwise be thermally over-stressed.

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The T200 measures the motor phase currents at a high frequency. Approximately 2 times per second, a new RMS current limit is calculated. The algorithm measures the RMS phase current for the last averaging period. It calculates the remaining amount of current for the next 0.5 seconds, for which the total current over the averaging period would be 20Arms. This remainder becomes the RMS current limit for the next 0.5second period.

The RMS current over the last averaging period is made available to the user. The "?LMR" command lists the actual RMS current value via the Hand Held Terminal interface.

6.9.5 Regeneration Resistor Protection Scheme

The regeneration function dissipates energy that is returned to the T200 from a decelerating load or from a counteracting torque. Regenerative energy dumping is handled by thermal dissipation through conduction of current through regeneration resistors. There are two resistive regeneration mechanisms in the T200:-

1. **Internal Regeneration Resistor**:- The T200 has an internal regeneration resistor which provides a 40W continuous/2.8kW peak dissipation capability. The internal regeneration resistor is protected by an Electronic Circuit Breaker. The breaker will inhibit the conduction of current in the internal regeneration resistor if the continuous conduction capability of the resistor is exceeded. In an application where high levels of regenerative power are fed back into the mains, an external regeneration resistor is needed. When the ratings of the internal regeneration resistor are exceeded, the Electronic Circuit Breaker will inhibit further conduction in the internal resistor. This will leave the external resistor to handle dissipation of further regenerative energy.
2. **External Regeneration Resistor**:- The conduction of the external regeneration resistor is monitored in order to detect if its continuous rating has been exceeded. Note that **the THRM_LIM Thermal Limit Active output of the T200 will activate if the external regeneration resistor's ratings have been exceeded.**

CAUTION:- The user's application should monitor for the activation of the THRM_LIM Thermal_Limit_Active digital output, and take action to reduce or remove further thermal stress on the T200, regeneration resistors and motor. If action is not taken then the external regeneration resistor may be damaged, or the fuse may be blown by an over-current.

Due to the possible variations in connecting the power section of T200's (see section 3.10, 3.11) the functionality for indication that the max. continuous regen power is exceeded can be adapted to the needs of the users application.

The following drive reactions can be selected***:***

- ***Regen Exceeded disabled***
  There will be no reaction of the T200 if the calculated continuous regen power exceeds the max. continuous regen power of the selected regen resistor.
  This is especially necessary in applications where the DC-Bus of T200's with internal PSU is paralleled. In such a configuration only one T200-X10 will have an external regen resistor attached. As the calculated regen energy is based on the assumption that an external regen resistor is connected the calculated regen energy of all drives without an external regeneration resistor is wrong and the warnings are misleading.

WARNING:- It is the users responsibility to ensure that the Regen Exceeded functionality is only switched off when no external regen resistor is used for this T200. There is no other indication that the cont. regen power is exceeded. Exceeding continuous regen power will damage the regen resistor and can cause the resistor to catch fire.

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- ***Regen Exceeded Enabled***
  Mode 1 (Warning Indication):
  As soon as the max. continuous regen power is exceeded digital output J1/19 will be switched off and E6 or U6 will be displayed on the 7-segment display.
  This warning is not a latched warning. I.e. as soon as the calculated regen power is less than the max. continuous regen power output J1/19 will be switched on and E6/U6 will no longer be displayed.
  If this warning occurs the first time since the drive is enabled this warning will be put in the error logfile as well.

- **Mode 2 (Drive disable):**
  As soon as the max. continuous regen power is exceeded digital output J1/19 will be switched off, E6 will be displayed on the 7-segment display, the T200 performs a Quick Stop and disables. U6 will be displayed until the drive is reenabled.
  Regen Exceeded is a latched fault. I.e. the indication U6 will be displayed until the drive is reenabled. This allows the user to figure out the reason for the Quick Stop. Output J1/19 will be switched on again as soon as the cont. regen power is no longer exceeded. This is to allow reenabling the T200 via the PLC.
  The message "Regen Exceeded" will be put into the error logfile.

Note: Output J1/19 is the "Thermal Limit Active"-output. This output indicates as well if the torque is limited due to a thermal limitation

The Regen Exceeded functionality can be enabled or disabled via the Regen Resistor Configuration box in WinDrive as described in Section 7.10.1.8 or via the Hand-Held-Terminal command "RE". Default is Regen Exeeded functionality enabled.

The drive reaction if the continuous. regen power is exceeded can be selected via the Regen Resistor Configuration dialog box in WinDrive or via the Hand-Held-Terminal command "ORM".

MOOG offers a range of regen resistors with the appropriate fuses for short circuit protection as described in section 3.13. If the user do want to use a different regen resistor the appropriate parameters of the resistor need to be set up.

The parameters can be set up either with WinDrive (see section 7.10.1.8) or via a Hand-Held-Terminal-Command.

The Hand-Held-Terminal-Command to set up the external regen resistor is: "ORR"

"Regen Resistor"
"Resistance [Ohm]"
"10 [Ohm]"
"?"
"Power [Watt]"
"200 [Watt]"
"?"

The default value and the max. regen power depends on the size of the T200. Default values are:

	Regen resistor resistance	Max. continuous power
T200-310	10Ω	200W
T200-410	10Ω	600W
T200-510	10Ω	600W
T200-610	4Ω	2500W
T200-710	4Ω	2500W

Range for the resistance: 4Ω...100Ω.
Range for the max. continuous regen power: 10W...10000W.

The calculated continuous regen power can be read either with the POD-Command "?LRR" or via WinDrive. This value is only sensible if an external regen resistor is connected to the T200. The value can be read out independent of the regen exceeded functionality.

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6.10 Encoder Simulation Function

The Encoder Simulation generates incremental encoder formatted output signals from a resolver position transducer. See Section 3.17 for an electrical description of the interface. The following signals are generated:-

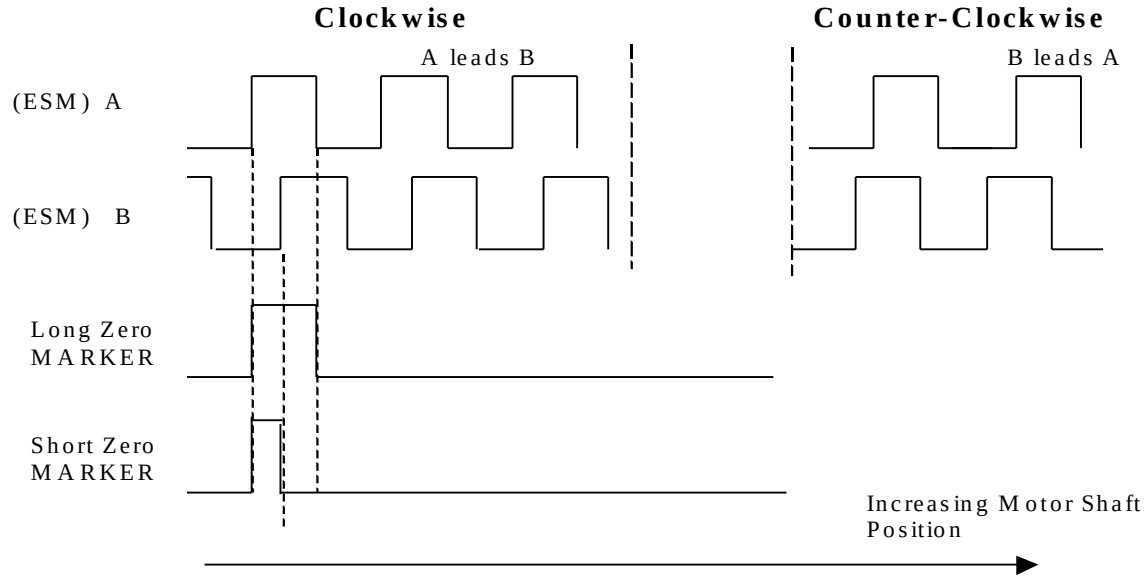

Figure 6.24:- Encoder Simulation Signals on Connector J7

The T200 implements two types of encoder simulation:-

1. ***High Bandwidth Encoder Simulation ("ESM3"):-*** This mode is recommended when the T200 is used in torque mode. The encoder simulation is carried out directly via analog hardware, with a feedback bandwidth of between 800 and 1000Hz. In this case the Number of Lines per Revolution is limited to the values 128, 256, 512 or 1024.
2. ***Flexible Line Count Encoder Simulation ("ESM1"):-*** This mode is recommended when the T200 is used in velocity mode. In this case the encoder simulation is implemented as a hybrid hardware and software module, and the feedback bandwidth is limited to approximately 400Hz.

The user must set the Number of Lines per Revolution parameter to an even number between 128 and 8192. If the User sets the Number of Lines per Revolution to a value of 128, 256, 512 or 1024, then the high bandwidth solution is chosen. If the user selects any other value then option 2) above is selected automatically by software. For both options 1) and 2) above the following software configurable options are available:-

- ***Zero-Marker-Offset:-*** The user may specify an offset (in mechanical motor shaft degrees) of the Zero-Marker of the Encoder Simulation output, with respect to the motor's own resolver-position sensor natural zero position.
- ***Marker-Length***:- Long Marker and Short Marker (see Figure 6.24 above) options are provided, as user selectable items.

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Note on Maximum Speeds:- The T200 Encoder Simulation Output is galvanically isolated. There is a maximum rate of pulses which may be transferred without loss of position information, through the isolation circuitry. The maximum pulse rate for the Channel A, Channel B and Zero-Marker is 200kHz. The user is informed by the WinDrive interface what is the maximum motor rotational speed for that number of Lines-Per-Revolution.

NOTE on Line-counts and Control Modes

ESM3 Linecounts (128, 256, 512 or 1024) are recommended for use when the T200 is operated in torque mode.

Other even line-counts (any even number between 100 and 8000, excepting those listed above as ESM3 linecounts) can be used when the T200 is operated in velocity mode

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6.11 Incremental Encoder Input

A quadrature incremental encoder input is provided on the T200. This encoder is not used for motor commutation purposes, but for feedback of relative position information to the Point motion control software or CAN interface system. The encoder interface accepts Channel A, Channel B and Zero Marker Differential Inputs in RS422 electrical format. A position latch function is also provided via connector J1, such that the encoder position is latched when the latch digital input transitions from inactive to active (i.e. current flows in the input).

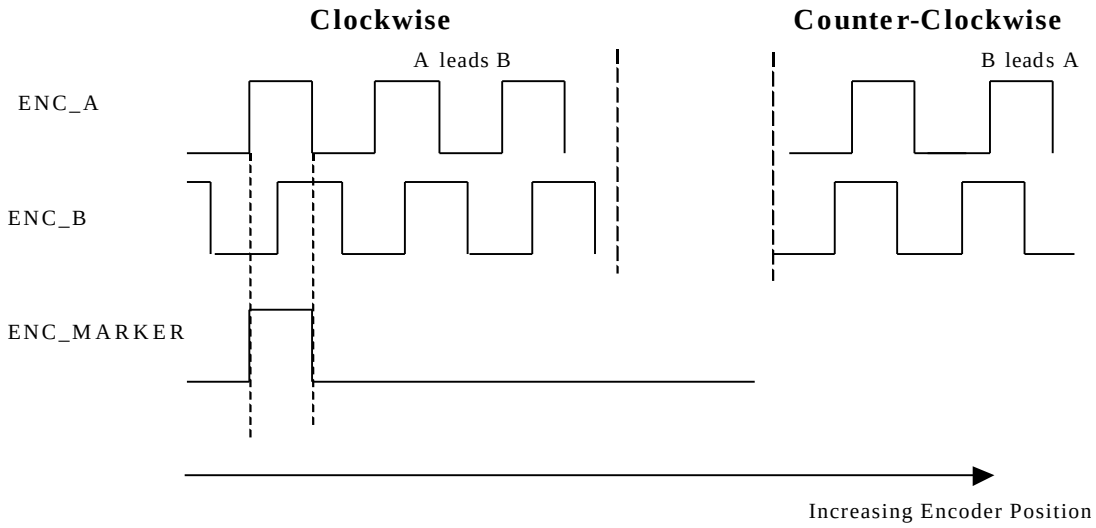

Figure 6.25:- Quadrature Incremental Encoder Input on J5

Specification Area	Specification Description
Maximum Line Frequency	Up to 1MHz Line Frequency (i.e. 4MHz edge frequency)
Input Voltage Range	Input Line Voltages are RS422 compatible.
Channel Input Impedances	Encoder Input is terminated with 120Ohms impedance
Encoder Fault Detection	The following faults are detectable:- Disconnected encoder lines (via monitoring of encoder voltages)
Position Registration Latch	The Position Registration Latch input is provided as a means of latching position upon detection of an event. The encoder position is latched within 1us of the inactive to active transition of this input.
Voltage Supply for Encoder	The T200 provides a 5V non-isolated supply for an external encoder. Note that an internal resetable fuse in series with the output will provide protection in the event that the external encoder device goes short circuit.

Table 6.7:- Incremental Encoder Input Specification

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Note that the following user programmable parameters are available for the Encoder Input:-

Number of Lines per Revolution:- The user may program this parameter to set the number of encoder lines per revolution of the motor shaft. This allows the T200 software to translate a rotary encoder's shaft position into its own internal position units for motion control calculations.

Zero-Marker Offset:- The user may program the offset (in lines) between the encoder's actual zero-marker and that which is registered in software. This function is reserved for future motion control functionality.

Present Position:- The present position of the encoder, in lines, may be examined by reading this parameter. This feature is useful for debug of encoder cabling and setup.

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6.12 Stepper Motor Interface

In Stepper Motor Inerface Mode the T200 can be used to replace a stepper motor if the dynamics of the stepper motor do not satisfy the requirements of the application. This mode allows as well an easy implementaiton of an electronic gearing. In Stepper Motor Interface Mode the T200 operates in Position Mode. This means that the Position Loop needs to be tuned for proper operation. Tuning of the Position Loop is described in Section 6.6.3. Setup with the WinDrive Graphical User Interface is described in Section 7.10.1.3.

In Quadrature Mode, the edges of ENC_A and ENC_B will generate a movement of ¼ of a step, i.e. each edge is 1 count. The relative phase of ENC_A and ENC_B will determine direction. For example, if the number of steps is 1024 and a 1024 line encoder is attached, then the motor shaft will turn 1 rev for 1 revolution of the encoder. The motor rotation is clockwise viewed from the motor flange when ENC_A leads ENC_B.

In Step and Direction Mode, ENC_A is used to trigger a step for each pulse on ENC_A, ENC_B is used to determine direction. When ENC_B+ is low and ENC_B- is high, the motor rotation is clockwise viewed from the motor flange. For counter-clockwise rotation, ENC_B+ must be high and ENC_B- must be low.

.

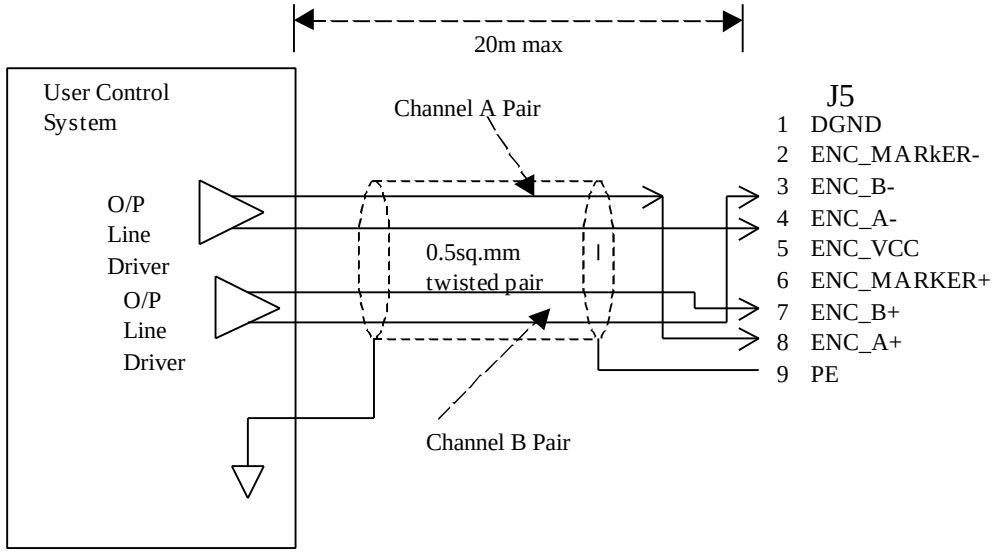

Figure 6.26:- Stepper Motor Interface Interconnect

If the T200 is in Stepper Mode the additional functionality is supported:

6.12.1 Hardware Limit Switches

If the drive is in Stepper Mode the HW Limit Switches can be enabled or disabled via the Hand-Held-Terminal command “OL” or via the “Limit Switch”-Window in WinDrive.

If a Limit Switch is hit and Limit Switches are enabled the drive ramps down to 0rpm in Position Mode with the Emergency Deceleration Rate and stays enabled. Further movements in the direction where the Limit Switch is hit are not possible. Movements in the other direction are possible.

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6.12.2 Following Error Detection

Indication and reaction of the drive when the Following Error Limit is exceeded

The "Speed/Torque Achieved" output (SPD/TORQ_ACHVD pin 21 of J1), is used to indicate to the user that the Following Error Limit is exceeded. As soon as the Following Error Limit is exceeded the SPD/TORQ_ACHVD output will be turned on. The SPD/TORQ_ACHVD output will stay turned on until the drive is disabled. The Following Error will be clamped to the Following Error Limit.

The 7-segment display will display "E4" if the Following Error Limit is exceeded."E4" is ba sed on the actual Following Error. I.e. if the drive catches up with the stepper pulses "E4" will no longer be displayed even when the SPD/TORQ_ACHVD output is still switched on.

If the Following Error Limit function is disabled (parameter set to 819200) the max. following error will be clamped to 50revs but there will be no user indication. Neither the SPD/TORQ_ACHVD output will be set nor "E4" will be displayed.

Setting of the Following Error Limit parameter

The max. allowed Following Error can be set up via the Dynamic Error (incs) in the WinDrive "Tracking Monitoring" window or via the POD command "SFFE"/"LFFE".The Following Error Limit need to be set up in increments. One motor revolution equals 16384 increments.
The parameter range is from 1024incs up to 819200incs. Any value beyond this range will cause a parameter error. The default value is 819199 increments (49.99 revolutions). The value of 819200 increments (50 revolutions) disables the Following Error Limit feature.

The Static Error does not apply. In WinDrive the Static Error will be greyed out if the drive is in Stepper Mode.

If in Stepper Mode the Drive Status Window displays "Following Error Exceeded" instead of "Speed/Torque Achieved" ("Set Point Achieved").

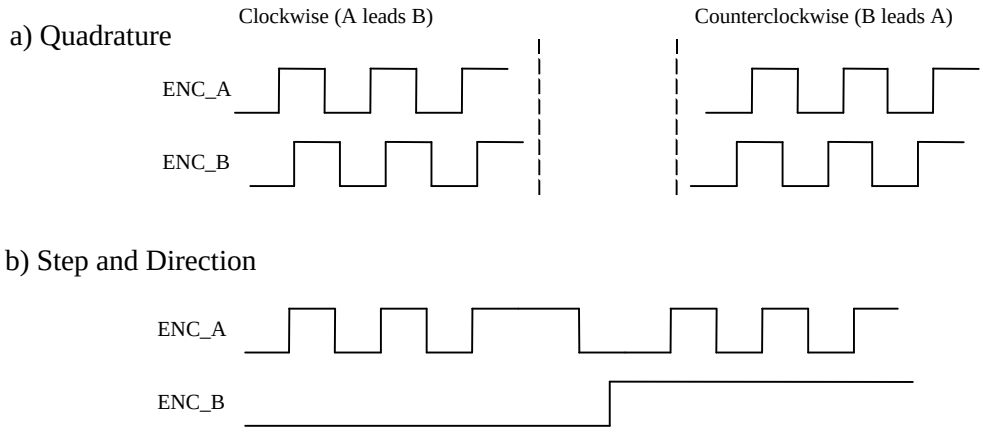

Figure 6.27:- Stepper Motor Interface Mode Signals on Connector J5

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6.13 Communications Interfaces

6.13.1 Axis Identification

See Section 3.18 for an overview of set-up of the axis-ID switches to set the T200 communications network address.

6.13.2 Communications Protocol

The T200 supports two protocols over its RS232 and RS485 communications links. These are:-

1. **Hand Held Terminal Pneumonics Protocol**. Simple 1, to 5 letter strings (followed by a <CR> Carriage Return) are used as command verbs which operate on particular parameters. The user enters a parameter value where appropriate. This protocol is used to support simple interfaces like the Hand Held Terminal or PC-based Terminal Emulation Programs (e.g. MS-Windows HyperTerm). This protocol is described in Section 8.
2. **'PSC' Protocol**. This protocol is intended as an interface to machine controllers via RS232 and RS485. It supports read and write of many data types, including floats, longs, integers, booleans and file-blocks. This protocol is described in this section.

6.13.2.0 Introduction

This specification describes the serial set-up protocol that allows access to T200 parameters over RS232 or RS485 serial networks.

T200 acts as a 'slave' device that only responds to messages sent by a Host 'master' controller. The Host can be any PC, PLC or other intelligent device that is capable of implementing the communication protocol. Use of the serial channel permits the control Host to read or modify most T200 parameters .

T200 parameters can be **4** bytes (**Long** or **Float** parameters) or **2** bytes (**Word** parameters) in size. Each parameter also has an identifying number appropriately called the **Parameter Number**. All data is represented as 2's complement, sign extended with the least significant byte as the first byte in a muli-byte value.

6.13.2.1 Serial Link Signal Specification

Communications Parameters Specification

- Baud rate 9600
- Start bits 1
- Stop bits 1
- Parity None
- Data bits 8

Signal Connections

Serial connections on the T200 Card are accessed via a 9 way D type female connector designated **'J4'** . Refer to Section 3.18 for wiring details.

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6.13.2.2 MESSAGE / REPLY FORMATS

Message Transmission to T200

All messages transmitted to T200 will be assembled in the following format:

Byte	Use
1	Number of bytes to follow (i.e. Message size - 1)
2	Address of T200
3	Command code
:	Command data
:	
:	
N	Additive checksum modulo 256

Note:

- All numbers are restricted to 8 bits (0..255)
- The T200 address for RS232 or single node RS485 is **'0'** .
- Delay from start of message to end of message must be less than 0.25 seconds
- For multi-node RS485, addresses from 1 to 127 must be used to address individual nodes (RS485 not currently implemented) .
- On a multi drop network, the transmitter must be disabled within 5mS of sending the last byte of the message. This allows the T200 to acknowledge the message sent.
- The content of the command data depends on the command code .

T200 Reply to Host Transmission

All T200 replies to the Host will be assembled in the following format:

Byte	Use
1	Number of bytes to follow (i.e. Message size - 1)
2	Master address incorporating slave address.
3	Command code
4	Acknowledge status
:	Acknowledge data
:	
N	Additive checksum modulo 256

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The address refered to by byte 2 is made from a bitwise OR between the T200 'slave' address and the Host 'master' address (Master fixed at 80 hex). For RS232, address = **80** hex or **128** decimal .

The 'acknowledge status' byte has the following **bit** definitions:

Bit	Meaning
0	Reserved
1	Acknowledge (Command OK)
2	No Acknowledge (Command NOT OK)
3-7	Reserved

An acknowledgement will normally be received after approximately 10ms, though this may vary greatly depending on the command sent, the amount of data transmitted (in the command or response), and the "load" of the application within the T200.

As a comparison, the standard "time out" period used in WinDrive is 5 second for a parameter read/write, and up to two seconds for each paragraph of block data read/written.

6.13.2.3 MODIFYING T200 PARAMETERS

Message Transmission to T200

The command code for modifying a parameter is **02**. The data required is:

- **Parameter number** (least significant byte followed by most)
- **Parameter write value** (2 or 4 bytes depending on parameter size). The order is from least significant to most significant byte .

To modify a parameter, the following message (series of bytes) should be sent to the T200:

	Write Two Byte Parameter		Write Four Byte Parameter	
Byte	Value	Meaning	Value	Meaning
1	07	Length of command	09	Length of command
2	00	Address	00	Address
3	02	Command (write param)	02	Command (write param)
4	P0	Param no (least significant)	P0	Param no (least significant)
5	P1	Param no (most significant)	P1	Param no (most significant)
6	D0	Param val (least significant)	D0	Param val (least significant)
7	D1	Param val (most significant)	D1	Param val (next significant)
8	CK	Checksum	D2	Param val (next significant)
9			D3	Param val (most significant)
10			CK	Checksum

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T200 Acknowledgement to Modify Parameter

There is no data returned with an acknowledgement to a parameter write command. The RS232 (slave address 0') acknowledgement would be:

Byte	Value	Meaning
1	4	Length of command
2	128	Address
3	2	Acknowledge write parameter
4	2	Acknowledge status
5	136	Additive Check sum MODULO 256 of 4, 128, 2, 2

Example

To modify the parameter **UPar1** (Parameter Number **46300**, **4** bytes) to the value **8000**, the following bytes should be sent:

Byte	Value	Meaning
1	9	Length of command
2	0	Address
3	2	Write parameter
4	220	Least significant part of Parameter Number 46300
5	180	Most significant part of Parameter Number 46300
6	64	Least significant part of Data value
7	31	Data Byte 2
8	0	Data Byte 3
9	0	Most significant part of Data Value
10	250	Additive Check sum MODULO 256 of 9, 2, 180, 220, 64, 31

The T200 acknowledgement will be as follows:

Byte	Value	Meaning
1	4	Length of command
2	128	Address
3	2	Acknowledge write parameter
4	2	Acknowledge status
5	136	Additive Check sum MODULO 256 of 4, 128, 2, 2

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6.13.2.4 MONITORING T200 PARAMETERS

Message Transmission to T200

The command code for monitoring a parameter is **01**. The data required is:

- **Parameter number** (least significant byte followed by most)
- **Size of parameter** to read (2 or 4 bytes).

To monitor a parameter, the following message (series of bytes) should be sent to the T200:

Byte	Value	Meaning
1	06	Length of command
2	00	Address
3	01	Command (read param)
4	P0	Param no (least significant)
5	P1	Param no (most significant)
6	SZ	Parameter size (2/4)
7	CK	Checksum

T200 Acknowledgement to Monitor Parameter

The acknowledge 'data' for a parameter read command is the 'value of the parameter' to be read. The value may be 2 or 4 bytes long, and will be transmitted in the order of least significant to most significant bytes:

	Acknowledge Two Byte Parameter Read Command		Acknowledge Four Byte Parameter Read Command	
Byte	Value	Meaning	Value	Meaning
1	06	Length of command	08	Length of command
2	128	Address	128	Address
3	01	Command (read param)	01	Command (read param)
4	02	Ack Status	02	Ack Status
5	D0	Param val (least significant)	D0	Param val (least significant)
6	D1	Param val (most significant)	D1	Param val (next significant)
7	CK	Checksum	D2	Param val (next significant)
8			D3	Param val (most significant)
9			CK	Checksum

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Example

To monitor the parameter **UFlag1** (Parameter Number **46316**, **2** bytes) the following bytes should be sent to T200:

Byte	Value	Meaning
1	6	Length of command
2	0	Address
3	1	Read parameter
4	236	Least significant part of Parameter Number 46316
5	180	Most significant part of Parameter Number 46316
6	2	2 Byte parameter
7	169	Additive Checksum MODULO 256 value of 6, 1, 236, 180, 2

If the value of **Uflag1** is **- 5** , the T200 acknowledgement would be:

Byte	Value	Meaning
1	6	Length of command
2	128	Address
3	1	Acknowledge read parameter
4	2	Acknowledge Status OK
5	251	Least significant part of Data value
6	255	Most significant part of Data Value
7	131	Additive Checksum MODULO 256 of 6, 128, 1, 2, 251, 255

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6.13.2.5 BLOCK DATA FORMAT

Write Block Data to T200

Block data is different from parameter data in that it may be relatively large. Block data is written to the T200 in sections of up to 64 bytes, known as paragraphs.

The command code for writing a block of data to the T200 is **18** . The data required is:

- **Block number**.
- **Paragraph number**.

Paragraphs should be written in the correct order (starting at 0), and should all be 64 bytes long except for the last, which may be up to 64 bytes long.

To write a paragraph of block data, the following message (series of bytes) should be sent to the T200:

Byte	Value	Meaning
1	LN	Length of command (Paragraph size + 5)
2	00	Address
3	18	Command (Write paragraph of block data)
4	PA	Paragraph no
5	BL	Block number
6	DA0	Data byte 0
7	DA1	Data byte 1
:		
N+6	DAN	Data byte N
N+7	CK	Checksum

T200 Acknowledgement to Block Data Write

There is no data returned with an acknowledgement to a block data write command. The acknowledgement would take the form:

Byte	Value	Meaning
1	4	Length of command
2	128	Address
3	18	Acknowledge write paragraph of block data
4	2	Acknowledge status
5	152	Additive Check sum MODULO 256 of 4, 128, 18, 2

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Read Block Data from T200

Block data is read from the T200 in sections of up to 64 bytes, known as paragraphs.

The command code for reading a block of data from the T200 is **17** . The data required is:

- **Block number**.
- **Paragraph number**.
- **Number of bytes to be read**.

Paragraphs should all be 64 bytes long except for the last, which may be up to 64 bytes long.

To read a paragraph of block data from T200, the following message (series of bytes) should be sent to the T200:

Byte	Value	Meaning
1	06	Length of command
2	00	Address
3	17	Command (Read paragraph of block data)
4	PA	Paragraph no
5	BL	Block number
6	LP	Length of paragraph
7	CK	Checksum

T200 Acknowledgement to Block Data Read

The acknowledge data for a block data read command is the value of the data to be read. The acknowledgement will take the form:

Byte	Value	Meaning
1	04	Length of command
2	128	Address
3	17	Acknowledge read paragraph of block data
4	2	Acknowledge status
5	151	Additive Check sum MODULO 256 of 4, 128, 17, 2

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6.13.3 Parameter Set Description

A detailed description of the T200 parameter set can be provided on request. See Section 11 for phone numbers and addresses of Moog Sales outlets.

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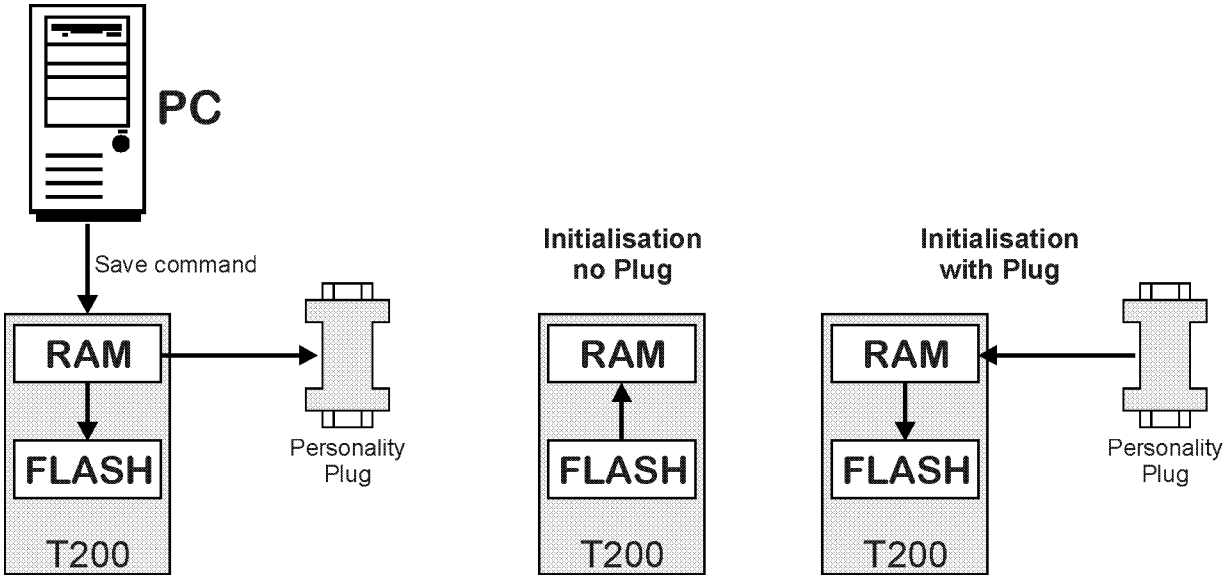
6.14 Parameter Storage

The T200 provides non-volatile storage for user-programmable parameters in both its internal Flash, and via the Personality Plug module.

Parameter Storage and initialisation



There are four user-configuration data storage locations of significance to the user.

1. **T200 Flash database (non-volatile storage):-** The T200 internal non-volatile Flash provides storage for all user parameters and for the POINT application program. The T200 draws it's parameter set from internal Flash when no Personality Plug is connected to the serial port J4.
2. **T200 Personality Plug Database:-** The Personality Plug provides an additional storage facility. If a T200 powers up or resets up, and the module is detected, then the personality module database will take priority over that of the internal database. The contents of the internal Flash databse will automatically get overwritten with the Personality Plug database.
3. **T200 RAM Database:-** The RAM database is the operational database for all online database operations. All parameters are transferred from non-volatile storage to RAM (during power up and reset) and from RAM to non-volatile storage (during parameter save). The T200 operates only with the data from the RAM database.
4. **PC-based .log files:-** User parameters sets are stored in ASCII .log files which can be inspected using standard ASCII text editors.

All T200 parameter transactions take place via the RAM Database. For example, it is not possible to alter the Flash database without altering the RAM database. Download of a PC-based .log file will only update the RAM database. An explicit command to save the RAM database to the Flash and personality plug databases has to be given in order to save the RAM parameters to non-volatile storage.

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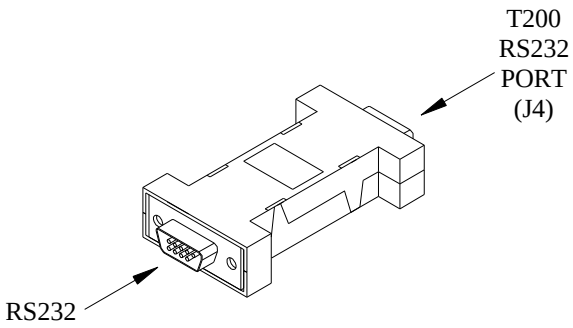
6.14.1 Personality Plug

The Personality Plug (Part No.: C25226-001) is a module which allows permanent storage of all T200 user parameters. The module allows the configuration of the T200 without a PC. I.e. in case a T200 need to be replaced in the field the T200 can be configured in connecting the plug to the serial interface J4 and powering up the T200.



The following paragraphs describe saving and restoring of user parameters.

Saving using Windrive

- Click on the '***File***' menu then the '***Save to EEPROM***' option. Click on the '***Save***' button. When '***Successfully saved to EEPROM***' message pops up the process is complete. The plug can now be removed.

Saving using a Handheld terminal

- At the '>' prompt, type '***C***' and press the '***Enter***' key. When the '>' prompt appears the process is complete. The plug can now be removed.

When the configuration has been saved, the user should correctly identify the plug using the label supplied on the side of the plug.

Saving the Custom Point Configuration

- Establish communications using the MOOG EUI (Engineering User Interface) program.
- Type the command '***dbcontrol 2***' and press the '***Enter***' key. When the '*** OK***' message appears, the process is complete. This will take several seconds, but when it has been completed the plug can then be removed.

When the configuration is restored from the plug, the configuration that is already stored in the T200 Internal Flash will be over-written.

Care should be taken to ensure that the configuration is correct before activating the motor as erratic behaviour can result.

Restoring a Configuration from the Plug

To restore the configuration, remove all power from the T200 drive. Insert the plug into connector J4 on the front of the drive. It is recommended to apply only 24V power to the drive. The drive will then over-write the configuration in the internal flash. If this is successful, these parameters will then used to configure the drive. In the case of an error, no error code will be indicated on the display of the T200. The user should therefore verify that the configuration has been loaded correctly using Windrive or a Handheld terminal before applying the 220VAC supply to the drive.

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6.14.2 Format of Log Files

An example .log files is shown below. It contains:-

- A description of the application, date, user notes etc.
- A Listing of the units which are used for Torque, Temperature, Current etc.
- A parameter-by-parameter listing of values.

This file format is relatively easy to review and modify. The example listed below is intended to be indicative of the file structure and is not rigorous in listing all T200 parameters.

```
; File Name :       AXIS12.LOG
; User Name :       B. McDuff
; Company :         MOOG
; Date :            13. September. 2000
; Application :     Bend INC
; Controller Type:  T200-310
; Software Version: C09931-009
; Comment :         T200 Metal-bending Application at Bend INC

; Unit Information :
;*Torque=Nm
;*Temperature=DegC
;*Current=Arms
;*KT=Nm/Arms
;*Velocity=RPM
;*Inductance=mH
;*Inertia=kgcm2

; Motor Name (Block 12):
#12 = G424-400

; T200.CFG FILE
; Feb 17, 2000

CNFG.ACCESSPARAMS = TRUE
MOTOR.CURRENTLIM = 9.999904
MOTOR.CONTCURRENT = 4.800000
MOTOR.KT = 0.540000
MOTOR.NOMINALSPD = 5500.000000
OBS.INERTIA = 3.100000
MOTOR.POLES = 12
MOTOR.RTT = 2.700000
MOTOR.MAXIMUMSPD = 8000.000000
RESOLVER.POLES = 2
MOTOR.THERMPRES = TRUE
MOTOR.LD = 3.500000
MOTOR.LQ = 3.600000
MOTOR.ILOOPGAIN = 6
MOTOR.VDCBUS = 320.000000
MOTOR.CONFIG = TRUE
```


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```
RES.OFFSET = 0.000000
CNFG.ACCESSPARAMS = FALSE
REFERENCESELECT = 1
ANALOG.OFFSET = 0.000000
VELOCITY.SCALE = 8000.000000
FG.VELOCITY = 0.000000
FG.TORQUE = 0.000000
FG.DUTYCYCLE = 50.000000
FG.VELOCOFFSET = 0.000000
FG.TORQUEOFFSET = 0.000000
FG.PERIOD = 1.000000
VELLOOPGAIN = 0.010000
INTEGRALTIMECONST = 0.200000
COMP.SELECT = 4
OBS.ENABLE = FALSE
FILTER.FREQ = 190.985931
MANUALMODEDISABLE = FALSE
LIMITSW.DISABLE = TRUE
QSTOP.DECEL = 10000.000000
FP.SIGNAL.TPA = 8
FP.SIGNAL.TPB = 1
IT.CONTCURRENT = 4.800000
IT.PEAKCURRENT = 9.999904
IT.TIME = 1.000000
THERMAL.SELECT = 2
RS485.USERAXISID = 0
NORMALTORQUELIMIT = 5.400052
REDUCETORQUELIMIT = 0.540005
NORMALVELOCTYLIMIT = 8000.000000
REDUCEVELOCTYLIMIT = 800.000000
WARNING.VELOCITY = 2000.000000
WARNING.VELOCITYTIME = 0.050000
RATELIMIT.TORQUE.RISETIME = 0.000400
RATELIMIT.TORQUE.MAX = 300.000000
RATELIMIT.ACCELTIME = 0.000400
RATELIMIT.VELOCITY.MAX = 10000.000000
ESM1.POSITONOFFSET = 0.000000
ESM1.LINECOUNT = 1024
ESM1.MARKERWIDTH = 1
POSITION.SCALE = 1.000000
VELOCITY.OFFSET = 0.000000
AUTOANALOG.OFFSET = FALSE
QUICK.STOP = FALSE
ENC.LINECOUNT = 0
ENC.ZEROMARKEROFFSET = 0
TRIGGER.ENABLE = 0
TRIGGER.FLAG = 0
TRIGGER.MODE = 0
TRIGGER.PREVDATA = 0
TRIGGER.LEVEL = 0
POSLOOPGAIN = 6.000000
POSLOOPINTTIMECONST = 50.000000
VELFEEDFORWARDGAIN = 0.000000
TORQUEFEEDFORWARDGAIN = 0.000000
```


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```
FG.ACCEL = 100.000000
FG.TRAVERSE = 0.000000
FG.STOPFLAG = FALSE
ENC.LINECOUNT = 0
ENC.ZEROMARKEROFFSET = 0
DIGIN.REFVEL0 = 0.000000
DIGIN.REFVEL1 = 0.000000
DIGIN.REFVEL2 = 0.000000
DIGIN.REFVEL3 = 0.000000
STEPPERIN.SCALING = 0
STEPPERIN.COMMAND = 2
CAN.COMMCYCLEPERIODUS = 6000
CAN.COMMANDWINDOW = 2000
CAN.ACTUALWINDOW = 2000
CAN.POSITIONSCALING = 1
CAN.KBAUDRATE = 1000.000000
CAN.DIRECTIONFLAG = FALSE
CAN.MODE = 2
LIMIT.POSITION.CLK = 99999999
LIMIT.POSITION.CCLK = 99999999
LIMIT.POSITION.DISABLE = FALSE
LIMIT.SWITCH.DISABLE = TRUE
LIMIT.SWITCH.POLARITYFLAG = TRUE
BRAKEON.FAULTFLAG = TRUE
STATICLOOPERROR = 1000
FOLLOWINGLOOPERROR = 400
HOME.CRAWLSPEED = 200.000000
HOME.ANGLE = 0.000000
HOME.SWITCHACTIVELOW = FALSE
CAM.TABLEDATA = 0
CAM.TABLEBOUNDSIGN = FALSE
CAM.TABLEBOUND = 2147483648
GEARBOXN = 1
GEARBOXM = 1
REFMACHINEANGLEFLAG = TRUE
CAM.SUBINDEX = 0
GRAVITYTORQUE.OFFSET = 0.000000
EMERGENCYMODE.BRAKINGSPEED = 50.000000
EMERGENCYMODE.TORQUELIMIT = 5.400052
TRIPPOINT.VELOCITY = 800.000000
TRIPPOINT.VELOCITY.HYS = 20.000000
TRIPPOINT.TORQUE = 0.540005
TRIPPOINT.TORQUE.HYS = 0.250000
TRIPPOINT.ENABLE = FALSE
FILTER.DAMPING = 0.700000
ANALOGTORQUELIMIT.DISABLE = FALSE
SERVOSTOP.DRVDISABLEDELAY = 0.100000
DISABLEBRAKE.DELAYTIME = 0.250000
FAULTINDICATOR.MODE = 1
STEPPER.FOLLOWERROR.LIMIT = 819199
EXTREGEN.DISABLE = TRUE
EXTREGEN.RESISTANCE = 10.000000
EXTREGEN.CONTPOWER = 200.000000
EXTREGEN.DRVDISABLE = FALSE
```


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```
INVERT.SYSTEMREADY = FALSE
INVERT.THERMALLIMIT = FALSE
```


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SECTION 7: WINDRIVE

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7.1 Introduction

Two user interface options are available:
a.) Graphical User Interface, WinDrive System.
b.) Hand Held Terminal. This is described in Section 8.

The WinDrive Graphical User Interface (GUI) is a standard windows based product used with MOOG's T200 Servo-Drive. WinDrive is used as a tool for the user friendly configuring, tuning and monitoring of a T200.

NOTE: The Hand-Held terminal device uses the same RS232 link to the T200 as the PC. The drive cannot communicate via both interfaces (PC and Hand Held Terminal) at the same time.

7.2 WinDrive Software Set-up

7.2.1 System Requirements

Minimum PC requirement 486 DX/2-66 processor,
8Mb RAM,
6Mb free on hard disk.

Operating System - Windows 3.1 or 3.11 (with *MS-DOS version 3.1 or later*),
Windows 95 or Windows NT (version 4.0 or later).

Screens sizes to fit - 640x480 display,
A VGA resolution video adapter.

7.2.2 Installation

To Install WinDrive, run the setup program on the distribution disks. This can be done using File Manager or Explorer, by double clicking on the setup executable, or by selecting Run from the File menu. For example, if the distribution disk is in drive A, then select/run the file A:\setup.exe. All other Windows programs should be closed when installing WinDrive, because the installation program needs to change certain Windows configuration files.

The installation program indicates the progress of the installation to the user, and allows for various installation options:

- The default target directory for WinDrive is C:\WINDRIVE. This directory can be modified if required.
- If any files in the target directory have the same name as those being taken from the distribution disk, the user is prompted to overwrite or cancel the copying of that file.

When the installation is complete, a new program group (MOOG WinDrive) will be created. The group will contain the WinDrive program (i.e. WINDRIVE.EXE), the WinDrive Help File (WINDRIVE.HLP), a Text File (README.TXT). For Windows 3.11, an uninstall utility is also placed in the group. Additional files are installed which are not listed in the group. The names and purpose of these files are listed in this help. The group will be added to the program task bar under Windows 95/NT, or will be added as a group icon under Windows 3.1.

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When setup is complete, remove the WinDrive Distribution Disk and reboot the PC. WinDrive can be run by double clicking on the WinDrive icon.

WinDrive can be uninstalled if required. In Windows 3.1 select the uninstall Icon in WinDrive's group. In Windows 95/NT select the Add/Remove Programs within the Control Panel.

7.3 Starting WinDrive

WinDrive can be run by double-clicking on the MOOG WinDrive icon under Windows 3.1, or selecting it from the Programs Task Bar under Windows 95/NT. When WinDrive is loading up, the WinDrive Logo is displayed, and the contents of WINDRIVE.INI are extracted:

1. If there are any problems in reading this file, an error message is displayed. Otherwise it will load and check the contents of a parameter database file specified by windrive.cmd.
2. It will then load and check the contents of configuration files specified for each Drive type (.cfg extensions).
3. WinDrive will then load and check the contents of motor database files (.mot extensions).
4. It will also extract information relating to Communications port, Data Logger, Tuning options etc.

Finally, if there are no errors in these files, dialog pop-ups prompt the user to configure the Communication Link between WinDrive and the T200.

7.3.1 Communication Link between WinDrive and Drive

WinDrive uses the serial port of a PC to communicate with a drive via the MOOG "Set-up Link" protocol, using RS232 or RS485 serial standards. WinDrive software and the physical link between the PC and the drive must both be configured correctly.

NOTE - The T200 requires some time to start communications after power-on or reset. Approximately 15s should be allowed after power-on or reset before establishing serial communications with the T200. A special start-up sequence is required to place the T200 in WinDrive communication mode. (This is necessary because WinDrive must send a particular character sequence (Ctrl P, S, C (0x10, 0x53, 0x43)) to switch the drive into the required set-up Link Protocol). This sequence is transmitted by WinDrive immediately after a communications port is selected. The T200 will accept this sequence only after self-initialization is complete. T200 self-initialization takes approximately 15s.

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NOTE on Communications Robustness between WinDrive and T200.
MOOG has made the communication between WinDrive and T200 as robust as possible by implementation of message error checking, and message-retransmission upon errors, as well as message time-out checking. Due to the wide variation in operating conditions under different versions of Windows and PC configurations, the user may experience occasional difficulties in establishing secure communications.

In particular, to re-establish communications after power has been removed from a T200, ensure that the WinDrive time-out message has appeared before re-applying power to the T200. If this is not done, then the user may experience intermittent Windows General Protection faults. If such an error occurs, the user should remove all power from the T200, re-apply power, then wait until the T200 has completed self-initialisation, before resetting communications from WinDrive.

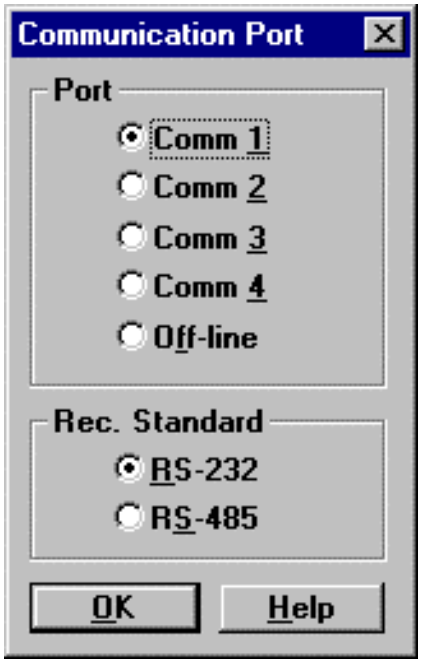

Figure 7.1: Communication Port Dialog Box

When WinDrive is started, the user is first prompted to select from one of 4 possible Comm -Ports on the PC in order to set WinDrive in On-line mode with the drive, or alternatively to operate the GUI in **Off-line** mode.

- If one of the Comm-Ports is selected, the user is prompted to select the Recommended Standard (RS) type, as either RS232 or RS485. The Comm-Port configuration is fixed to match the serial requirements of a drive and operates always at
    - 9600 Baud, with
    - No parity,
    - 8 Data bits and
    - 1 Stop Bit.
    - If RS485 is selected the user is also prompted to select the RS485 Axis Address.
- If **Off-line** is selected, the user is prompted to select from one of the three supported drives (T161 RMC, T164 DMC or T200).

NOTE - If the wrong communications port is selected, WinDrive will time-out after several seconds and display an error message box asking if off-line operation is required. This time-out will take approximately 20seconds, as 4 attempts to communicate are made, each lasting 5 seconds.

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7.4 RS232 and RS485 Communication

RS232 is a serial data standard, which allows WinDrive to communicate directly to a single drive. Both WinDrive software and the physical link between the PC and the Drive must be configured correctly, in order to establish communication.

The RS-Type must be set as RS232 at WinDrive start-up. If the user is unsure of the RS-Type, the RS-Type can be reset by selecting the Low Level/Reset Comm menu item. WinDrive then sends the initial character sequence (Ctrl P,S,C) to the drive, to switch into the required protocol. WinDrive generates requests to determine the drive type, motor and software version. A timeout of 20 seconds is implemented on these requests, which will result in an error message if WinDrive is unable to establish communication.

An RS232 connection must be made between the selected Comm-Port of the PC and the Serial Port 9-Way D-Type connector J4 on the front panel of the drive.

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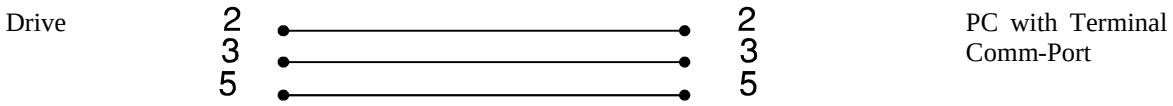
7.4.1 RS232 Connection

The RS232 port of the drive is configured as a modem. The connector pins on the Serial Port 9-way D-Type connector on the front-panel of the drive are as follows:

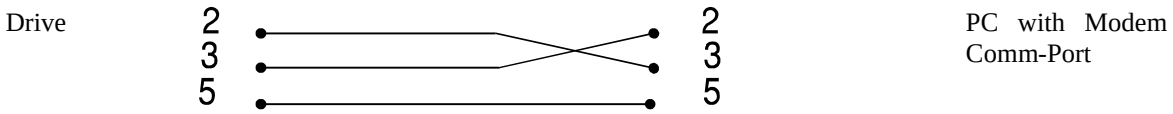
Pin 2 RS232 Receive Rx
Pin 3 RS232 Transmit Tx
Pin 5 Signal Ground

The diagrams below show the wiring required for an RS232 cable between a PC and drive.

Drive to 9 Way D Type (Terminal Equipment)

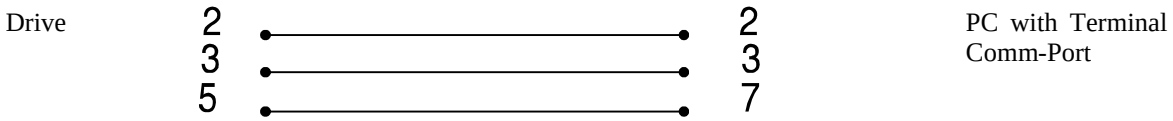


Drive to 9 Way D Type (Modem Equipment) See note below.

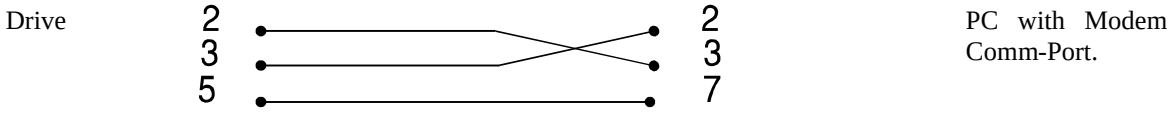


NOTE Modem Equipment configuration is what is typically used with most IBM compatible PC's.

Drive to 25 Way D Type (Terminal Equipment)



Drive to 25 Way D Type (Modem Equipment)



NOTE: D type lead is available from MOOG. MOOG's Order part Number is B75923 .

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7.4.2 RS485 Communication

RS485 is multidrop serial data standard, which allows WinDrive to communicate with a number of T200's, each of which has a unique Axis Address. The communications protocol is the same as for the RS232 link but demands that the drive address identifier be included in order to address individual T200's.

NOTE When using WinDrive, the RTS line of the PC Communications Port should not be used to enable the Transmitter of the adapter.

The RS-Type must be set as RS485 at WinDrive start-up. If unsure of the RS-Type, it can be reset by selecting the Low Level/Reset Comm menu item. The RS485 Axis Address must also be set at WinDrive start-up. This dialog allows the user to select the axis number, and also allows for a drop-down list of all previously accessed axes off the RS485 line. WinDrive then sends the initial character sequence (Ctrl P,S,C) to the drive, to switch into the required protocol. WinDrive generates requests to determine the drive type, motor and software version. A timeout of 20 seconds (i.e. including 3 retries) is implemented on these requests, which will result in an error message if WinDrive is unable to establish communication.

RS485 communication is achieved by using an RS232/RS485 adapter or converter. The RS232 side of the converter is connected to the selected Comm-Port of the PC. The RS485 side of the converter is connected to the drive via the RS485 port of the drive.

7.4.2.1 RS485 Interfacing Connection

RS485 communication is achieved by interfacing a suitable RS232/85 adapter between the PC and drive. Important aspects of the connection are that:

- Some RS232/RS485 adapter manufacturers suggest the use of RTS line on the PC's communications port, to enable the transmitter of the adapter. WinDrive does not control the RTS line, due to the fact that the RTS line cannot be accurately controlled because of latencies in the Windows Operating System.
- WinDrive expects and requires a local echo (Receiver sees what is transmitted) to be sent from an RS232/RS485 adapter.

Adapter Requirements
The following adapter and cable requirements should be met by any adapter which is used with WinDrive.

- Half Duplex Operation (Data Signals are both transmitted and received on two pairs wired in parallel (i.e. Tx/Rx (A) = RS485+, and Tx/Rx (B) = RS485-).
- Method of Enabling of Transmitter.
- Tx+ and Tx- Pull up/down resistors, (recommended values depend on adapter used).
- Screened twisted pair (nominal impedance 120 Ohms).
- Cable end termination with 120Ω resistors if cable length is over 20m.

In Half Duplex operation, the RS232/RS485 adapter must be able to enable its transmitter when the adapter is ready to transmit, and disable (i.e. tri-state) the transmitter when the adapter is ready to receive. Some adapters will use the RTS line from a PC, or other external signals, as an enable signal to the transmitter. Other adapters will implement the enabling of the transmitter internally.

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Example of PC Interface
If an external signal is required to enable the transmitter of the adapter, the Transmit Data pin from the PC can be used as an enable pin. An adapter can be wired to ensure that the transmitter is enabled when data is sent, thus actively driving Highs on the RS485 line.

If the RTS line is used by the RS232/RS485 adapter, the following adapter can be placed between the PC Communications port, and the RS232/485 converter. WinDrive uses only the Transmit Data, Receive Data, and Signal Ground Pins on the PC Communications port.

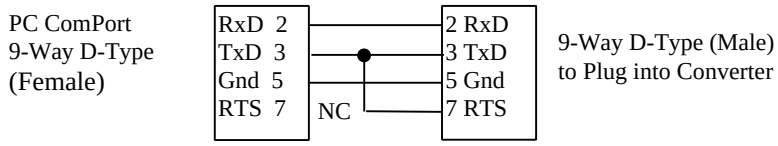

Figure 7.2: Adapter between PC and RS232/RS485 Adapter

For details of wiring for a specific RS232/RS485 adapter, consult the data-sheet for the particular device.

7.4.2.2 RS232/RS485 adapter

The RS232/RS485 adapter recommended by MOOG for operation with WinDrive and the RMC/DMC and T200 is PSM-EG-RS232/RS485-P/2D, PN2761392 from Phoenix Contact.

PC COMM PORT	SIGNAL	PHOENIX RS232	
		9-PIN D	COMBICON
1	SHLD	NC	NC
2	RXD	2	5
3	TXD-RTS	3 & 7	4 & 7
5	GND	5	8

T200 RS485	SIGNAL	PHOENIX RS485	
		9-PIN D	COMBICON
4	RS485 +	3	6
5	RS485 -	8	8
6	GND	2 - 7	4

Table 7.1: Wiring of PSM-EG-RS232/RS485-P/2D

For further information consult MOOG applications engineering.

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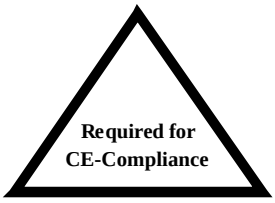
7.5 Password Protection

This dialog box appears at system start-up and is used to enter a User Password. Two levels of user access are supported:

- Access Level 0 = General User Access (Enable, Disable, and Monitor a Drive).
- Access Level 1 = Privileged User Access (Drive Tuning and Configuration plus all Access Level 0 privileges).

If a valid User Password is not accepted by the servo-drive, Access Level 0 will be invoked by default. At this level, changes to configuration and tuning parameters are not allowed.



NOTE: Access Level 1, Privileged User Access shall be restricted to technically qualified service and maintenance persons only.

Figure 7.3: Password Dialog Box

The Password must be a number between 0 and 9999 and is set to 0 when the MOOG WinDrive compatible servo-drive software is shipped. If password protection is not desired, this value should not be changed (just enter 0 and select OK).

If password protection is desired, the User password should be changed via the Password Change dialog box and saved to EEPROM (under the File menu). Once saved to EEPROM this password MUST BE KNOWN AND REMEMBERED by each User requiring configuration and tuning access (Access Level 1) for a specific servo-drive.

NOTE - In off-line mode, the password capability is disabled and the Password dialog box does not appear at start-up.

If the saved password is forgotten, a MOOG Application Engineer must be called to reset the saved User Password to a known value.

NOTE - If the Changed Password is not saved to EEPROM using Save To EEPROM in the File Menu, it will only be valid while power to the servo-drive is maintained.

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To change a saved password, the old password is entered in the Password Dialog box. The Change Password Dialog box may then be displayed by selecting the Change button in the Password Dialog box. The new numeric value should be entered in the Password field and the OK button selected. A message will appear informing the user that the User Password has been changed.

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7.5.1 Off-line Mode

Off-line Mode occurs when the PC communications port is not connected to a servo-drive, the servo-drive is not powered on, or the User has selected Off-line in the Communications Port Dialog box.

In off-line mode, the Password Dialog box will not appear since no actual servo-drive configuration or tuning can take place. Instead, a Controller Type Dialog box is shown, from which the desired controller type should be selected. Items in the various menu bars will be "greyed out" when not applicable to the selected servo-drive.

Access to the WinDrive Main Screen is available after selecting the controller type.

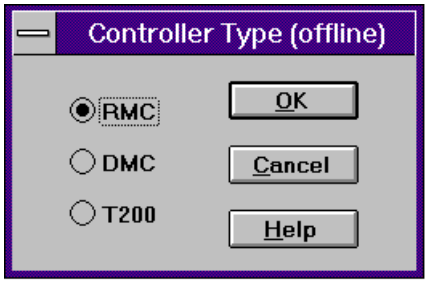

Figure 7.4: Controller Type (offline) Dialog Box

NOTE - In on-line mode the servo-drive type is read automatically from the drive.

7.5.2 Switching Between Communications modes

If the user needs, at any stage, to switch between communications ports (if more than one drive is being configured in RS232 mode), **Reset Comms** should be selected from the **Low Level Menu**. The user can also work off-line at any stage by selecting **Set Offline** from the **Low Level Menu**. When operating in RS485 mode, multiple servo-drives may be configured individually by selecting **Select Axis** from the **Drive Menu**. If an **Enable, Disable** or **Stop** command is required to be sent to all connected servo-drives, **Broadcast** should be selected from the **Drive Menu**.

7.5.3 WinDrive On-line Help System

The WinDrive Help System is started from the **File Manager** by clicking on the Help Icon, or when WinDrive is running, by pressing the **F1** key or from the **Help Menu**. Starting the Help system in any of these ways opens the Help Contents Dialog box which features a list of Help topics. Clicking on any of these topics opens a dialog box with a list of related topics.

When help is required for a specific subject, Search should be selected from the Help Menu. The Help contents will be listed in alphabetical order, double click on the item and then select it from the Topic Window. Click on **Go To** to open the appropriate Help Dialog box.

Help may also be started from all of WinDrive's dialog boxes. Click on the Help button in the dialog box to open the specific Help file for that dialog box.

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7.6 Main Window - Features

The WinDrive Main window is divided into several sections:

- Outer Frame - Standard Microsoft Windows Frame with minimise/maximise and exit Icons.
- Menu Bar - Pull-down menus to access all WinDrive features.
- Main Tool Bar - Icon buttons for various functions and commands.
- WinDrive Status Bar 1 - Compensator Mode/Drive Status/Fault Status/Axis ID (RS485).
- Main Window Button Console - Six buttons to access the primary configure/tune dialog boxes.
- Data Logger Plots - Contains the output of two data logging channels for drive parameters.
- Log File Display - Displays log file contents while recording, or a previously recorded log file.
- WinDrive Status Bar 2 - Read & Writes/Drive State/Limit Switches/GUI Mode/Logging/ Communications.
- PC Interface Bar - Tool Bar Help/Caps Lock/Num Lock/Scroll Lock.
- Floating Toolbar (when enabled) - Quick Stop/Enable Drive/Disable Drive buttons.

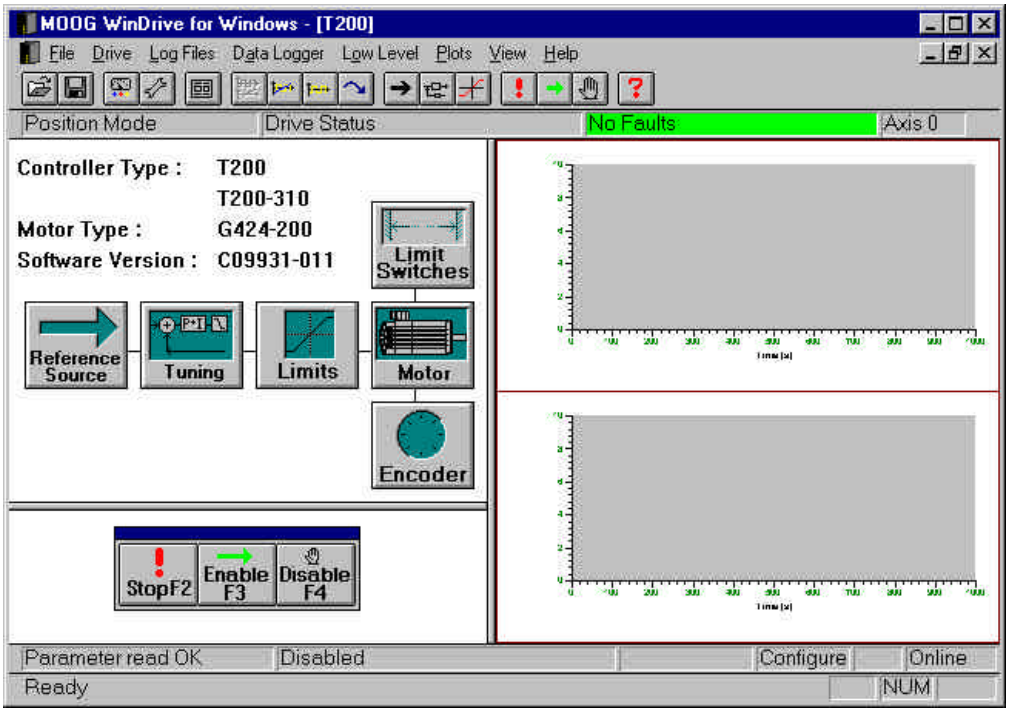

Figure 7.5: WinDrive Main Window

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The Main Window Button Console, Log File Display, and Data Logger Plots sections are part of a three way "splitter window". The mouse cursor converts to a vertical or horizontal bar as it moves over these vertical or horizontal window dividers. The size of each split section can be changed, by holding down the left mouse button and moving the window divider. The Button Console window has a minimum size, regardless of the application size.

7.6.1 Function Keys

F1 is used to open the WinDrive Help System. If there are no dialog boxes open, the Help Contents Page is displayed when the **F1** key is pressed. If the **F1** key is pressed while a dialog box is open and active, Help for that specific dialog box is displayed. Selecting the **Help** button within a dialog box has the same result.

F2 is used to Quick Stop (servo stop) a turning motor. The drive is still enabled after F2 is pressed and its position held constant. The drive must first be disabled before it can be enabled again to re-start the motor.

F3 is used to Enable a T200. If a reference source has been set-up, the motor should begin turning when the drive is enabled.

F4 is used to Disable a T200. If a motor is turning when **F4** is pressed, the motor will stop.

7.6.2 Shortcut Keys

Each of the WinDrive pull-down menus can be opened via the "Alt" key and the underlined letter in the menu option. E.g. the "Alt" and "F" key combination is used to open the **File Menu**. Once a given menu is displayed, the items inside can be selected by pressing a single keyboard letter.

Various dialog boxes can also be directly opened using a second set of "Shortcut Keys". If a menu item has this alternate shortcut key access, the key sequence will be displayed to the right of the menu item. The mouse can also be used to select menu options.

7.7 General Features

7.7.1 Floating Toolbar

The Floating Toolbar can be enabled by using the **View/Floating Toolbar** menu item, or by pressing the **Ctrl+F** key combination. The toolbar is always on top when enabled, and can be moved as required about the screen. **Drive Quick Stop (F2), Drive Enable (F3), and Drive Disable (F4)** commands are accessible from the Floating Toolbar. The buttons can be selected with the mouse or the appropriate function key. The (always on top) Floating Toolbar operates exclusively in the foreground, and may still be used if WinDrive is being run as a background task (the WinDrive application window must not be minimised within Windows for this feature to work).

Figure 7.6: Floating Toolbar

7.7.2 WinDrive Help System

On-line assistance is provided to the WinDrive user by the Help system. The WinDrive Help system can be accessed via **Contents** under the **Help Menu**, the **F1** key, or the **Help** button on each dialog box. Details of each WinDrive dialog box, field, and button are available from the Help system.
Shift-Up/Down Arrow and Shift Right/Left Arrow keys can be used to select splitter window bars. Subsequent use of Up/Down arrows can be used to move the splitter bars. The Tab key can also be used to toggle focus between dialog boxes in the View Menu.

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7.7.3 Main Window Button Console

The Main Window Button Console allows for quick access to the most frequently used dialogs. It consists of six icons which are selected in order to set, or adjust the main parameters required to configure a T200. From the Main Window Button Console, the Reference Source, Tuning Parameters, Velocity and Torque Limit values, Motor Type and parameters, Limit Switch and Encoder settings may be viewed and altered.

The functionality of the Button Console changes, dependent upon whether the T200 is in Configure or Tune mode. For example, if the T200 high power is enabled, setup of a motor is not allowed.

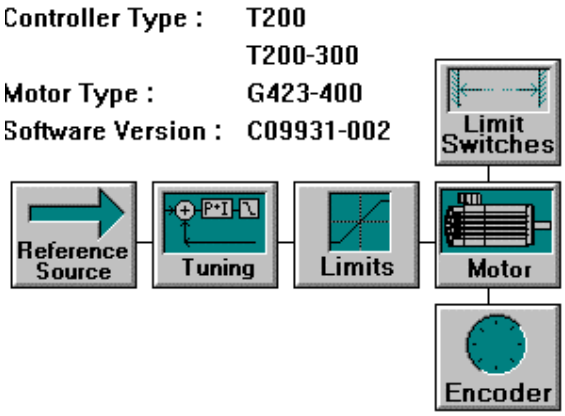

Figure 7.7: Main Configuration Console

7.7.4 Data Logger

The behaviour of a motor and servo-drive can be observed using the Data Logger Function. Two user configurable channels, for servo-drive and motor feedback, are provided to plot data in the Data Logger Plots Window. Logging of data begins either when the Data Logger is triggered by the user set trigger signal, or is automatically updated on a regular basis.

7.7.5 Auto Tuning (Velocity Mode Only)

Auto Tuning greatly reduces the time needed to configure and tune the T200's velocity loop gain parameters (Note that the Auto Tuner sets the velocity loop gains only). Auto Tuning tunes a drive automatically by applying a torque excitation signal to the motor. The motor response data is used to determine the characteristics of the motor and load, and in turn is used to tune the drive. Minimum input is required from the user. The user is prompted if he wishes to continue at all stages of the Auto Tuning process. Note that Auto Tuning is described in detail in Section 6.6.2.10.

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7.8 Menu Options

7.8.1 File Menu Options

- **Open** - Opens a previously saved log (file extension *.log) or Data Logger (file extension *.mdl) file.
- **Save** - Saves the current Data Logger or log file data to disk for future use.
- **Print Plots** - Three options are available from the **Print Plots** option:
  1. **Print Graph** - Prints the selected plot.
  2. **Print Page** - Prints plots for both Data Logger channels.
  3. **Print Options** - Allows printing parameters to be changed.
- **Print Logfile** - Prints the current log file.
- **Print Setup** - Printer and printing options are configured using **Printer Setup**.
- **Save to EEPROM** - Saves the current drive configuration to the servo-drive non volatile storage.
- **Configuration Upload** - Transfers the drive parameters listed in the *.cfg file from the drive to a specified log file.
- **Configuration Download** - Transfers parameters stored in a *.log file to the drive.
- **Passwords** - Allows the set-up and changing of servo-drive access passwords.
- **Exit** - Exits the WinDrive system.

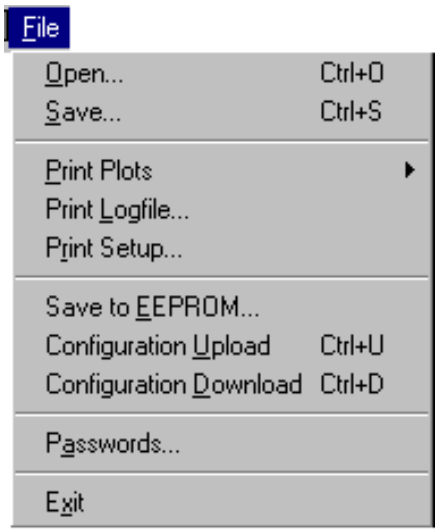

Figure 7.8: File Menu Options

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7.8.2 Drive Menu Options

Set-up – The following options are available from the Set-up option:

- **Reference Source** - Set the reference source for the servo-drive.
- **Tuning** - Adjust the drive tuning parameters.
- **Limits** - Set and adjust torque and velocity limits.

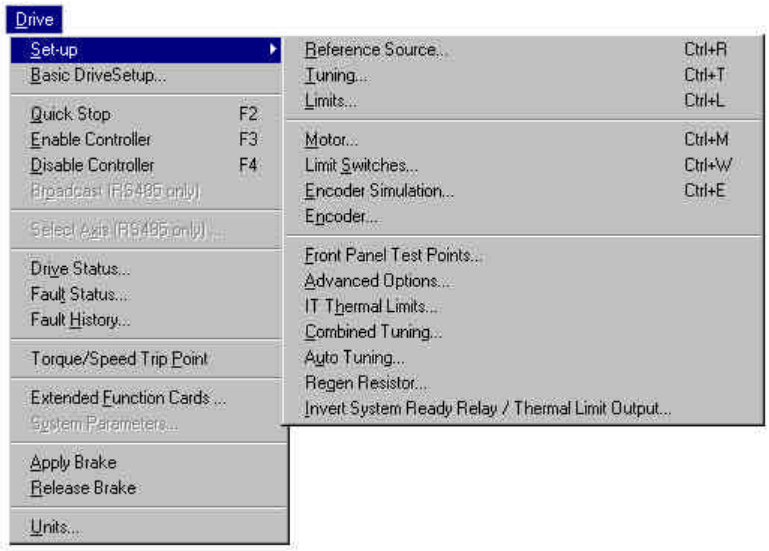

Figure 7.9: Drive Menu and Drive/Set-up Menu Options

- **Motor** - Motor parameters are entered using this option. For standard MOOG motors, parameters are selected automatically from a motor parameter database. A number of MOOG non-standard motors is listed in the non-standard motor database. Parameters for motors not listed in either of the databases, must be entered by the user.
- **Limit Switches** - Limit Switches may be enabled or disabled using this option and the quick stop deceleration entered or adjusted.
- **Encoder Simulation** - Sets and adjusts Encoder Simulation parameters.
- **Encoder** - Encoder input parameters are set by the user with this option.
- **Front Panel Test Points** - Two user configurable test points are available at the T200 Axis Signals connector, J1. The Front Panel Test Points option determines the output signal type at each test point.
- **Advanced Options** - Used for more precise drive tuning.
- **IT Thermal Limits** - Sets and adjusts the IT (current/time) thermal limits. If thermal foldback is being used, this option will be disabled.
- **Combined Tuning** - Combined Tuning opens a dialog box featuring tuning constants, function generator parameters and Data Logger options. Use of this option avoids skipping back and forth between dialog boxes whilst configuring a drive.
- **Auto Tuning** - Having entered servo-drive and motor information, **Auto Tuning** is used to tune a motor servo-drive combination automatically.

NOTE - While the **Auto Tuning** feature tunes a drive to a high degree of accuracy, for optimum performance, manual tuning should be used. **Auto Tuning** will always tune the T200 control loop parameters so that there is some safety margin in the controlled system.

- **Regen Resistor** - This dialog enables the user to configure the T200 for an internal or external Regeneration (Regen) Resistor, as well as determine the behaviour should the maximum regen power be exceeded.

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- **Invert System Ready Relay / Thermal Limit Output** - For certain applications, it can be desirable to invert the polarity of the System Ready Relay or Thermal Limit Output. These can be set in this dialog.

- **Basic DriveSetup** - A basic drive set up is the fastest means of manually tuning and configuring a drive. All parameters essential for the basic set-up are set by the user.
- **Quick Stop** - Performs the same function as the **F2** key or the Stop button of the Floating Toolbar. This function performs a servo-stop on the connected motor.

NOTE - The drive must be disabled before normal drive operation can be resumed, after a **Quick Stop** has been activated.

- **Enable Controller** - The enable controller function is available by pressing **F3**, pressing the Enable button on the Floating Toolbar and from the Drive Menu. This function enables the servo-drive to switch power to the connected servomotor.
- **Disable Controller** - Also available from the Floating Toolbar or by pressing **F4**, the disable function removes power from the motor.
- **Broadcast (RS485 only)** - Broadcast transmits **Stop, Enable** and **Disable** commands to every servo-drive in an **RS485** daisychain communications interface.
- **Select Axis (RS485 only)** - When operating in RS485 mode, each servo-drive is assigned an axis-identification number via the two Hex switches on the T200 servo-drive. **Select Axis (RS485 only)** determines which servo-drive is interfaced by WinDrive.
- **Drive Status** - Drive Status provides a table of current servo-drive data.
- **Fault Status** - Fault Status provides an overview of drive faults and warnings.
- **Fault History** - Fault History provides a list of errors recorded by the controller.
- **Torque/Speed Trip Point** - This dialog allows the user to set trip-points (which will in turn set digital outputs high), when torque or velocity exceed certain value ranges around a particular set-point.
- **Extended Function Cards** - Extended Function Cards displays which option cards have been detected by the WinDrive software.
- **System Parameters** - This option is only available in on-line mode and when Auto Tuning has been performed. It displays the full set of system parameters.
- **Apply Brake** - Applies the optional motor brake.
- **Release Brake** - Releases the optional motor brake.
- **Units** - The units in which WinDrive displays torque, temperature, current, kt (torque constant), velocity, inductance and inertia may be changed with this option.

7.8.3 Log Files Menu Options

- **Start Record** - In order to begin writing a log file, the Start Record option is selected. The log file window is automatically updated as new parameters and commands are entered. Current units are written to the window as soon as **Record** is selected.
- **Stop Record** - On completion of log file recording, Stop Record is selected.
- **Clear Record** - Clear record is used to erase the Log File Display Window. A **Save** option is displayed before the current log file is cleared.

Figure 7.10: Log Files Menu Options

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- **Logfile Player** - The log file player "plays" log files which send communication requests to the drive. Log files may be played as a continuous stream of commands or in a string, stepped through line by line. An **Echo to File** option allows the servo-drive response to each command to be saved to disk. A loop function allows the log file to be continuously played to the drive.

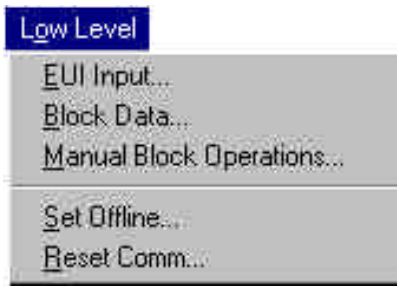
7.8.4 Data Logger Menu Options

Set-up - All Data Logger parameters are entered in this dialog box. The user can define a specific trigger variable to the software which determines when the Data Logger begins the recording of data.

- **Run** - The Data Logger Run dialog shows the current status of both data logging channels and provides access to the **Run** command which enables the Data Logger to record data.

Figure 7.11: Data Logger Menu Options

7.8.5 Low Level Menu Options



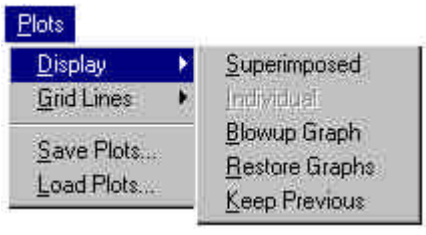
EUI Input - The EUI, or Engineering User Interface, provides access to individual servo-drive parameters, which, depending on user access level, may be read from or written to the drive.

- **Block Data** - Information on the motor type and the controller type, software version number and software version release date.
- **Manual Block Operations** - This dialog box allows the transfer of block data from a file to the servo-drive and alternatively from the servo-drive to a file.

Figure 7.12: Low Level Menu Options

- **Set Offline** - If working with a connected, powered servo-drive and the user wishes to operate off-line, this option should be selected.
- **Reset Comm**. - Reset Comm. is used if switching communications ports or switching from off-line to on-line mode.

7.8.6 Plots Menu Options



- **Display** - Several options are available from the Display option:

➢ **Superimposed** - Superimposes the two Data Logger plots to allow for ease of comparison.

➢ **Individual** - Displays the Data Logger plots individually.

➢ **Blowup Graph** - Expands the selected Data Logger plot to fill the Data Logger display window.

Figure 7.13: Plots/Display Menu Options

➢ **Restore Graph** - Restores undeleted graphs to the Data Logger Plot Display Window.

➢ **Keep Previous** - Stores the previous Data Logger plots in memory.

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Figure 7.14: Plots/Grid Lines Menu Options

- **Grid Lines** - Two options are available from the Grid Lines option:

➢ **Horizontal Grid** - Adds a horizontal grid to the current Data Logger plot.

➢ **Vertical Grid** - Adds a vertical grid to the current Data Logger plot.

- **Save Plots** - Saves the current Data Logger plots to disk for future use.
- **Load Plots** - Allows the user to load previously saved plots to the Data Logger plot display window.

7.8.7 View Menu Options

The **View Menu** determines whether the following features are visible or not:

Toolbar - The icons for general WinDrive use, the toolbar, may be concealed or revealed using the **View/Toolbar** menu option.

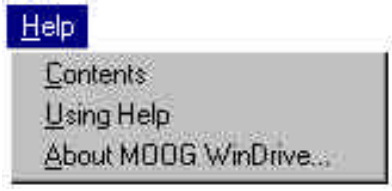
Status Bar - Showing servo-drive and software information, the WinDrive Status bar 2 at bottom of the WinDrive main window may be concealed, increasing the size of the Data Logger plot window.

Figure 7.15: View Menu Options

Floating Toolbar - When required, the Floating Toolbar may be displayed using the **View** option, also available with the **Ctrl + F** key combination.

The **View** menu also lists any open dialog boxes and if selected, "focus" is given to that dialog. This allows for transfer of focus between dialogs when the application is used without a mouse.

7.8.8 Help Menu Options



- **Contents** - Displays the contents of the WinDrive Help system.
- **Using Help** - Provides a full guide to using the WinDrive On-line Help system.
- **About MOOG WinDrive** - Gives information on the version of WinDrive software being used.

Figure 7.16: Help Menu Options

Figure 7.17: About MOOG WinDrive Dialog Box

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7.9 WinDrive Monitoring Features

7.9.1 Data Logger

WinDrive's Data Logger function is used for monitoring and recording system parameters. This information is read by WinDrive and plotted in the Data Logger Output Window. Before the Data Logger can be used, the operating parameters must be set-up, using either the **Data Logger Set-up** Icon, or the **Set-up** option from the **Data Logger Menu**.

a) Set-up

Channel - The Data Logger function has two channels for data recording, each one should be configured in turn. The following parameters must be set:

Data Logger Enable - The Data Logger channels must be enabled before they can gather data.

Vertical Axis Variable - This option determines what variable is plotted on the y-axis of the Data Logger plot, e.g. Torque Demand. The variable will be plotted in units which are suitable for it. Time, in seconds, is always plotted on the x-axis.

Horizontal Axis Number Of Data Points - Determines the number of sample points to be recorded by the Data Logger in the set Data Logger sampling period. The maximum number of points which can be recorded per channel is 4096.

Horizontal Axis Logging Rate - Determines how frequently data samples are recorded by the Data Logger. A logging rate of 1 will cause the Data Logger to record data from the servo-drive at each sample instant. Higher rates (e.g. every second or third sample) will reduce the time-resolution of the displayed data.

Pre-Trigger - Allows data to be gathered up to the point of the trigger occurring.

Post-Trigger - Data is gathered after the trigger has occurred.

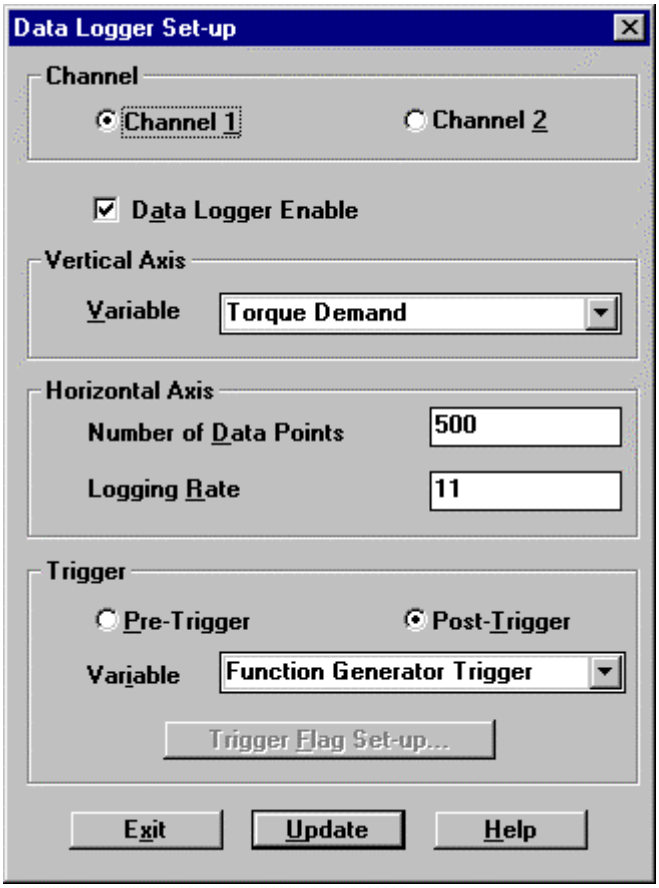

Figure 7.18: Data Logger Set-up Dialog Box

NOTE - The Data Logger Enable Checkbox must be checked for each channel before any data logging can be performed.

Trigger Variable - The **Trigger Variable** setting determines the parameter upon which the start of data logging depends, and is set to trigger data logging in three ways:

1. The **Function Generator Trigger** flag starts data logging when a function generator period starts.
2. If triggering is desired from some drive variable, select the **Trigger Flag** option as the **Trigger Variable**. In this case, a user-defined variable set in the **Trigger Flag Set-up** dialog will trigger the Data Logger.
3. The **DataLogger Sync** flag allows to begin recording of data when the **Run** button is clicked in the Data Logger Run dialog.

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Several parameters must be set by the user in the **Trigger Flag Set-up** dialog:

Data Trigger Enable - The Data Trigger feature must be enabled before it can trigger the gathering of data.

Rising Edge - When this option is selected, data recording will start when the **Trigger Source** variable rises above the value determined in **Trigger Level.**

Falling Edge - For **Falling Edge** mode, the **Trigger Source** variable falling below the **Trigger Level** will trigger the Data Logger.

Trigger Source - The **Trigger Source** is selected by the user from a list of possible variables.

Trigger Level - The **Trigger Level** determines above (**Rising Edge**) or below (**Falling Edge**) which level of the **Trigger Source** variable recording of data will start.

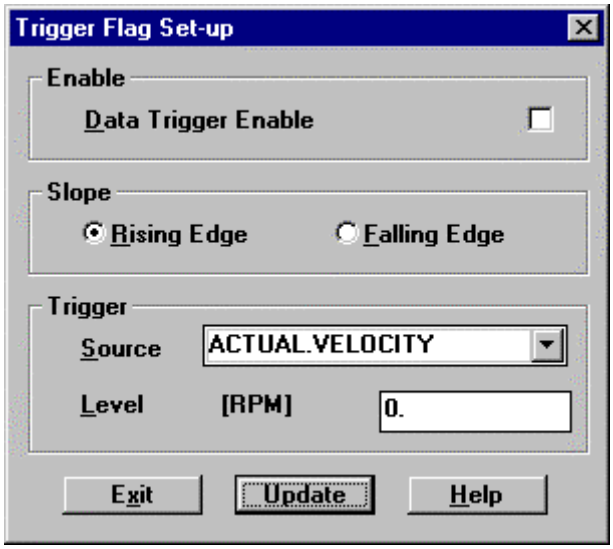

Figure 7.19: Trigger Flag Set-up Dialog Box

NOTE - When using the Trigger Flag option, the Data Trigger Enable Checkbox must be checked.

Figure 7.20: Data Logger Run Dialog Box

b) Data Logger Usage

When set-up of the Data Logger is complete, the Data Logger Run dialog is used to start the Data Logger.

Selecting Run from this dialog box begins the recording of data. Note that despite starting the Data Logger, information will only be recorded when the trigger variable value becomes true.

Following the completion of data logging, the information is plotted on charts in the Data Logger Display Window. The plot in the upper half of the display window is that of channel one, whilst the lower plot is that of channel two. The labelling of Data Logger plots is edited by double clicking on the chosen label. A Text Parameters Dialog box, with fields for text, font, color, size and style allows editing of the plot text.

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7.9.2 Engineering User Interface

The Engineering User Interface (EUI) is opened by selecting the EUI Icon or the **EUI Input** option from the **Low Level** Menu. The EUI dialog box has four main fields: the input (**Command**) and output (**Result**) displays, and **Command** and **Result History** fields. Three buttons, **Exit**, **Update** and **Help** are located at the bottom of the dialog box.

The EUI provides the user with a full set of system parameters, which are listed in the **Command** box drop-down list. This list can be opened by clicking on the right-hand arrow button of the **Command** box. By selecting a command and clicking on **Update**, the value of the selected variable is retrieved by querying the drive memory. When a query is sent, following a short pause, the response from the servo-drive is returned to the **Result** field and the **Result History** is updated. The EUI may also be used to write values to the drive. After a parameter name has been entered in the **Command** field, a space or an "=" sign should follow and the desired value entered for the parameter. This value will be written to the drive on pressing "Enter" or clicking the **Update** button.

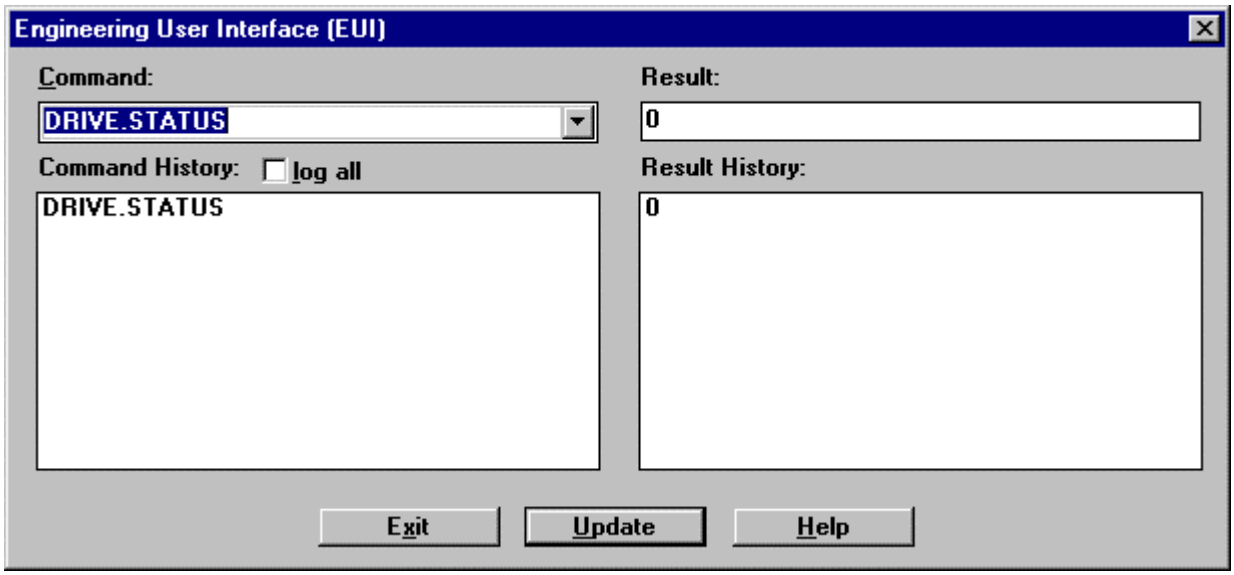

Figure 7.21: Engineering User Interface (EUI) Dialog Box

7.9.3 Block Data

The Block Data option is accessed from the Low Level Menu. Block data is held in the memory of the connected drive. The Block Data Dialog box provides the following data:

Block No.	Data (Chars)
12	Motor Type
13	Servodrive Type
14	Software Version
15	Release Date

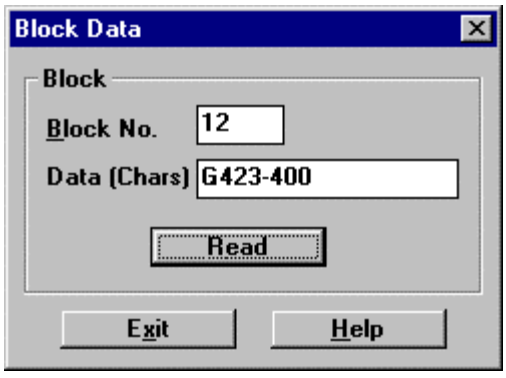

Figure 7.22: Block Data Dialog Box

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7.9.4 Manual Block Operations

Block data may be saved to disk for future use by selecting **Manual Block Operations** from the **Low Level** menu, selecting **Save to File**, as well as the **Block Data Number** and **Length**, entering the path and **File** name and clicking the **Update** button. This information may be saved in either **BYTE** or **Word** format. To recall block data from disk, select the **Read from File** option from the **Low Level** menu, enter the block data path and **File** name (or use the **Browse** facility) and click on **Update**.

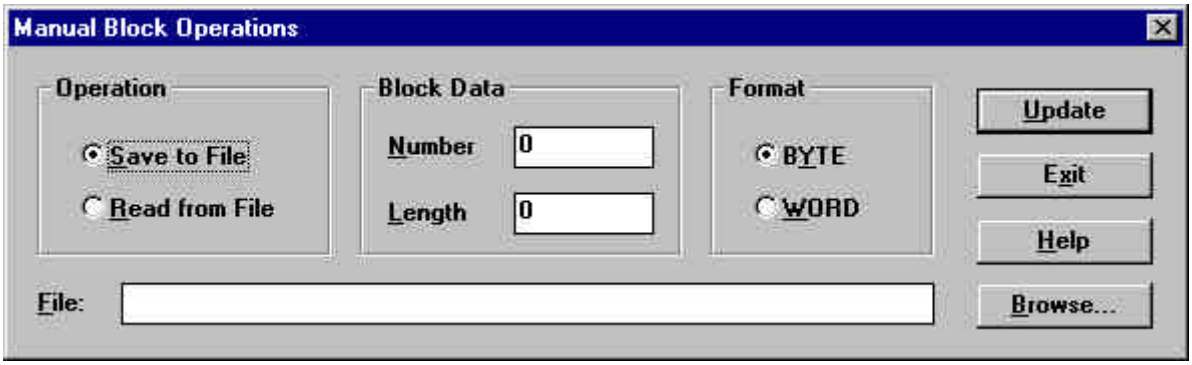

Figure 7.23: Manual Block Operations Dialog Box

7.9.5 Front Panel Test Points

Two programmable analog output channels are available with every WinDrive compatible servo-drive. The output at each of the channels is set with the Front Panel Test Points Dialog box.

Accessed via the Set-up option in the **Drive** menu, the Front Panel Test Points Dialog box contains two lists of variables which may be assigned to each test point, a field labelled **Velocity Scaling** and a button labelled **Zero Displayed Position**.

If either of the **Front Panel Test Points** is set up to indicate a velocity variable, then the **Velocity Scaling** parameter entered in this dialog box will determine the scaling of that velocity variable at this Front Panel Test Point.

The **Zero Displayed Position** button should be clicked before starting a motion of the motor when an Actual Position is assigned to a test point. This zeroes the displayed position to give a correct reading.

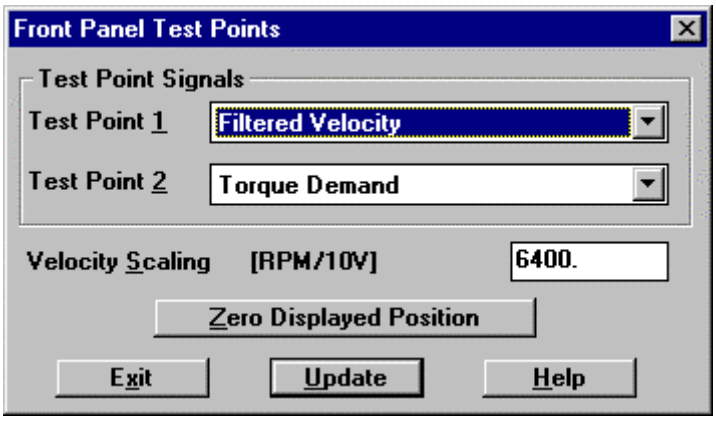

Figure 7.24: Front Panel Test Points Dialog Box

CAUTION - Changing the Velocity Scaling value will modify the actual motor velocity if the Analog Input is selected as the servo-drive's reference source. If the overall machine control configuration is a position loop, the gain of the position loop will also be modified by changing the Velocity Scaling value.

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7.9.6 Drive Status

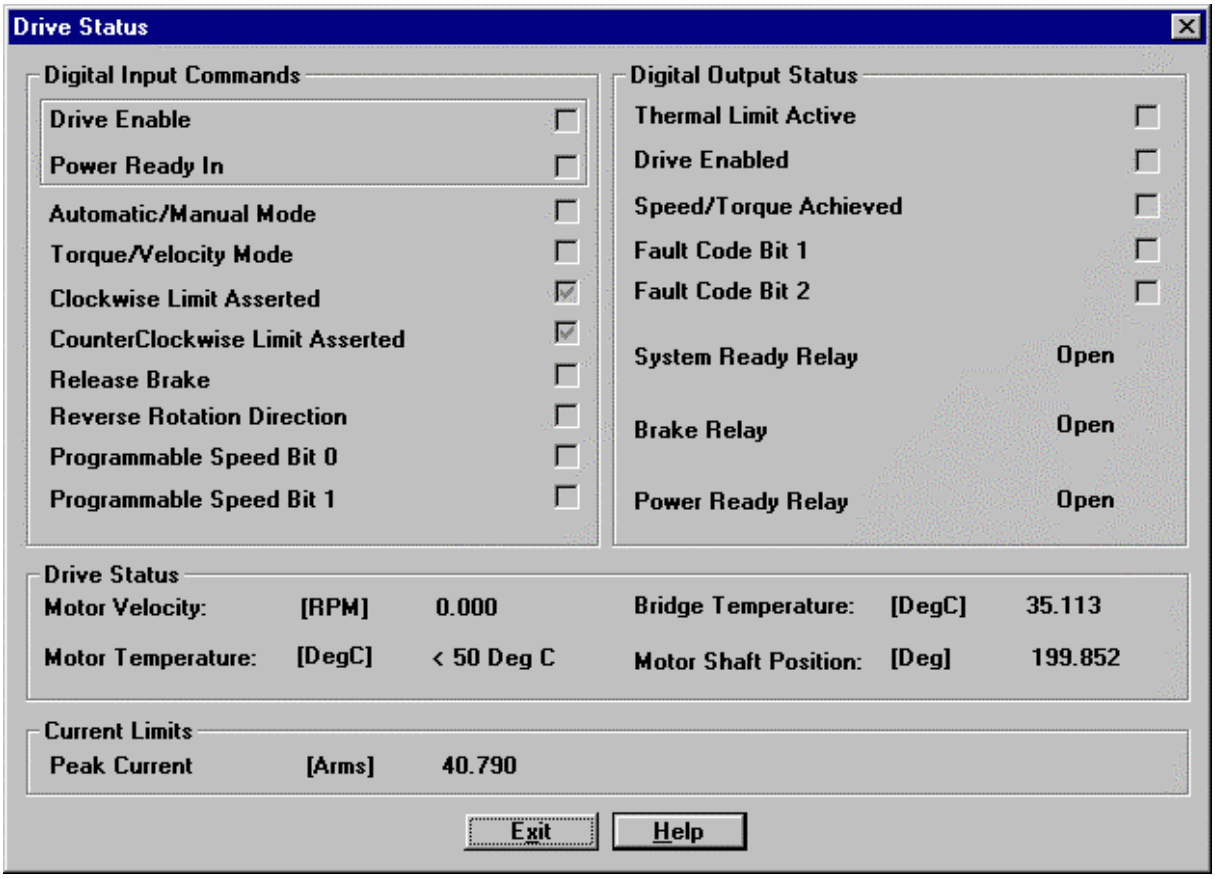

Figure 7.25: Drive Status Dialog Box

Available by selecting **Drive Status** from the **Drive Menu**, the Drive Status Dialog box provides a table of current drive and motor parameters and is constantly updated by the WinDrive software. The appearance of this dialog box changes to facilitate Reference Source settings. This dialog shows all essential system parameters and is useful in both diagnostic and system querying procedures.

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7.9.7 Fault Status

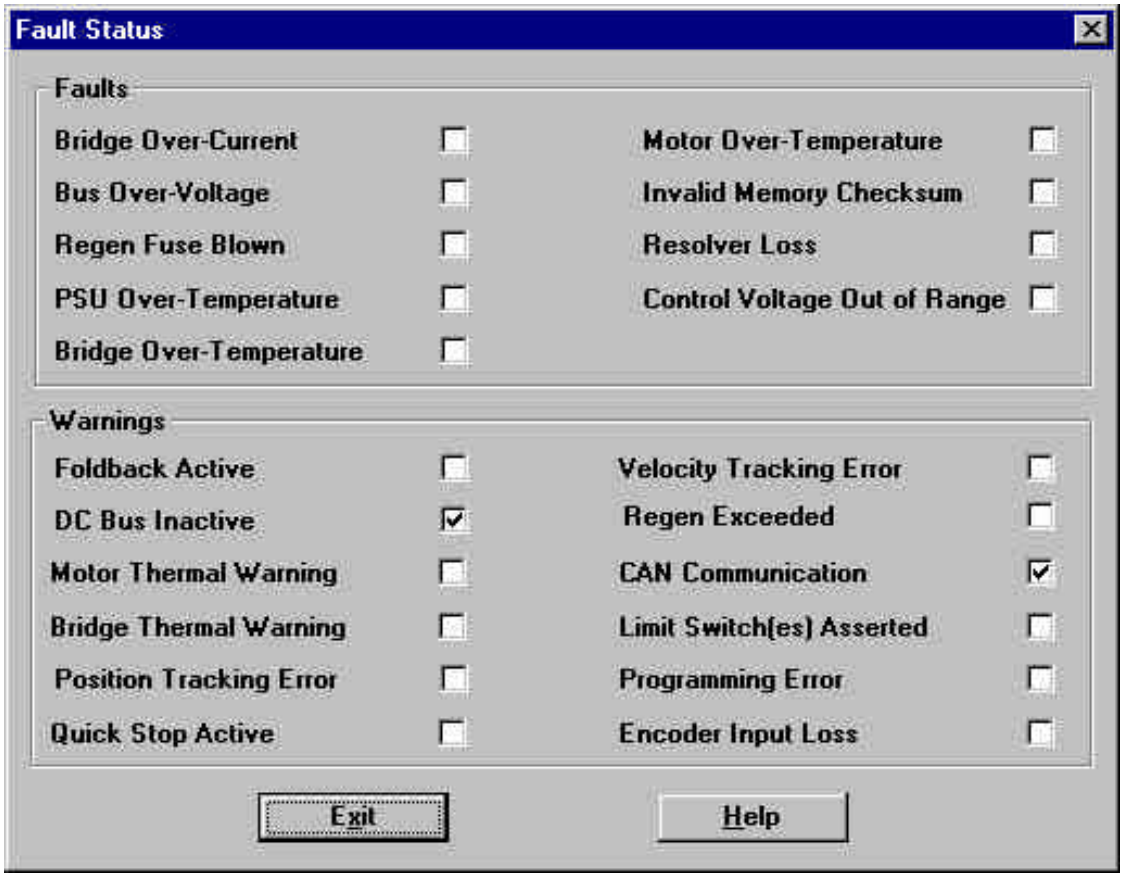

Figure 7.26: Fault Status Dialog Box

This dialog is available by selecting **Fault Status** from the **Drive Menu**. This dialog box provides an overview of current fault and warning conditions and is constantly updated by the WinDrive software. This dialog is useful in diagnostic as well as system querying procedures.

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7.9.8 Fault History

The T200 provides a means of uploading and displaying the fault history data stored in the T200 non-volatile storage.

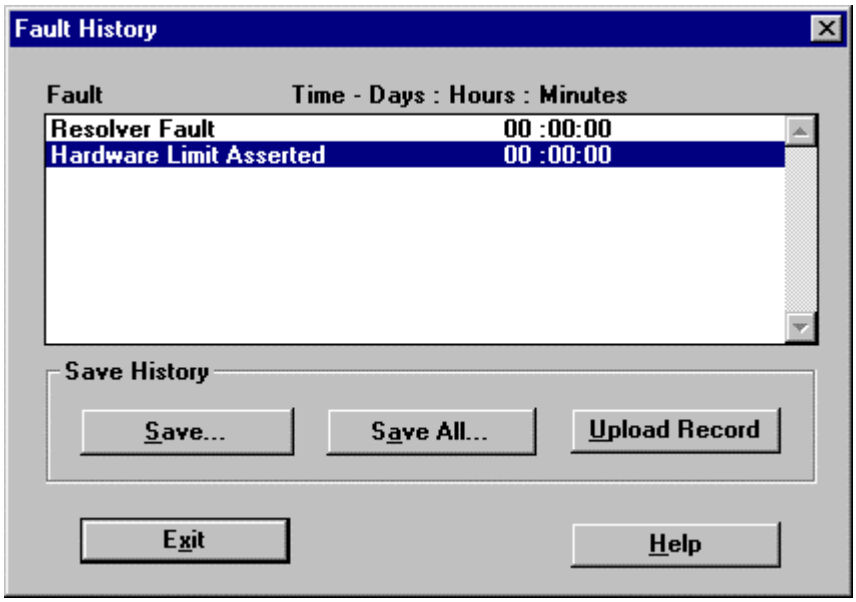

Figure 7.27: Fault History Dialog Box

Using this dialog box, all error data recorded by the drive can be accessed. When the dialog opens, the first 10 records of errors are uploaded automatically. A further 10 records can be uploaded by clicking on the **Upload Record** button. The viewed records can be saved by clicking on the **Save** button. All records can be saved by clicking on the **Save All** button.

The time index is organised such that the most recent fault is displayed at time 00:00:00 and the previous faults are displayed with a negative time index. If more than one fault occurs at the same time, then the individual faults will be displayed with the same time index.

The drive can only track time while there is logic power applied, since it does not have a real-time clock. When the drive is powered, a record is maintained of the time the drive is enabled and the time it is disabled. When a fault occurs both times are written to the flash memory in the drive along with the fault code. The sum of these times is the time between faults.

Fault (records): This list box displays the fault records read from the drive. Ten records are displayed (if available) when the dialog is opened, and when the **Upload Record** button is clicked on.
Save: This button allows the present faults displayed to be saved to a file. The user is prompted for the same information that is used in Configuration Upload i.e. File Name, Customer, software version etc.
Save All: This button allows all of the recorded faults to be saved to a file. The list box is not updated when this occurs. The user is prompted for the same information that is used in Configuration Upload i.e. File Name, Customer, software version etc.
Upload Record: This button allows the user to upload and automatically display the next 10 fault records.
Fault History Upload: This dialog allows the user to also write helpful information to the .FLT file. This information is located at the top of the file

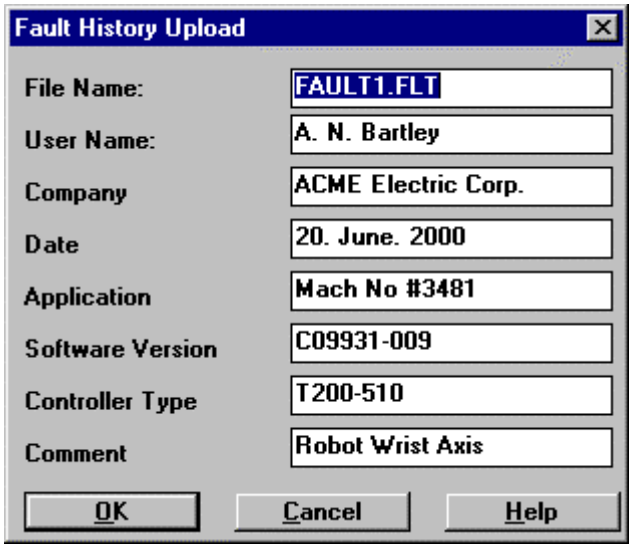

Figure 7.30: Fault History Upload Dialog Box

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7.10 Drive Set-up

The drive can be configured in either Position Mode, Velocity Mode or Torque Mode via WinDrive. Note that the T200 defaults to the Velocity loop configuration mode, with an analog ±10V reference type. Configuration of the T200 into other modes besides Velocity Mode is described in Section 6.

7.10.1 Basic Velocity Mode Drive Set-up

This section describes a basic set-up method for a servo-drive, using the **Basic DriveSetup** option from the **Drive Menu**. A sequence of dialog boxes follows the selection of this option.

7.10.1.1 Units Set-up

Unit Type	Metric	Imperial
Torque	Nm	lb-in
Temperature	°C	°C
Current	A	A_{rms}
KT	Nm/A Nm/A_{rms}	lb-in / A_{rms}
Velocity	RPM	RPM
Inductance	H or mH	H or mH
Inertia	kg cm^2 or kg m^2	kg cm^2 or kg m^2

Table 7.2: Available Units

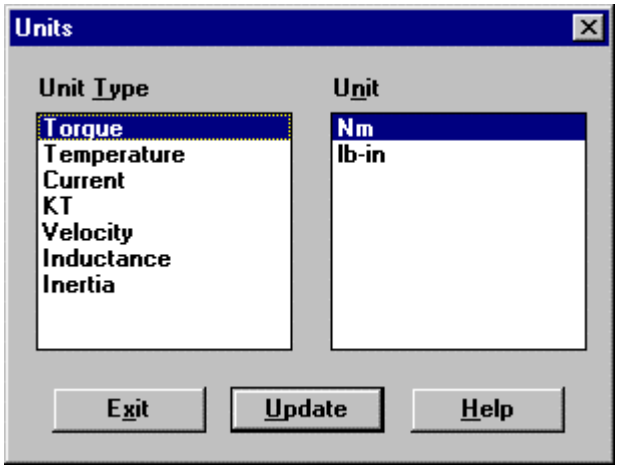

Figure 7.31: Units Dialog Box

Prior to configuring the drive, the Units Dialog box should be opened from the **Drive Menu**. The units in which the parameters torque, temperature, current, KT (torque constant of motor), velocity, inductance and inertia are measured should be set as required by the user. **Update** should be clicked to store the units to memory. These units are typically available in metric or imperial units.

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7.10.1.2 Select Motor Dialog Box

The motor is selected by the user. Motor types are divided into standard (MOOG standard range) and non-standard motors (MOOG custom designed or non- MOOG motors). See Section 4 for a review of motor naming terminology and standard or non-standard motors. Note that all MOOG G3XX and G4XX Global motors are included in the standard motor database. When not running the Basic DriveSetup sequence from the Drive menu, the user selects the motor type by clicking on the **Motor** Icon (see Section Main Window Button Console) or, by selecting the Drive/Set-up/Motor menu option.

NOTE: The T200 supports MOOG 's D31X series and 30X series of servo-motors, for backward compatibility purposes. Consult MOOG applications engineering for support of these products with the T200.

CAUTION: The user should ensure that his machine is placed in a safe non-operational mode when configuring the motor. When the motor selection is downloaded to the T200, the T200 high power will be removed and control of the motor-shaft and load will be lost. The machine-position may need to be re-referenced when the configuration is complete.

a) Standard Motor Selection

WinDrive contains a database of the MOOG standard motor. The user can select either the motor's electrical type or the motor model as the search-key for the database. If the user has purchased a motor which has a 'non-standard' motor-model, then the user can select the electrical 'type' rather than the 'model' from the Select Motor dialog's **Motor List** (See Section 4 for an overview of the motor nameplate data). The **Standard** field is ticked by default in the **Motor Type** section.

Having selected the correct motor from the **Select Motor** Dialog box, the **Download** button should be clicked to download the motor data set to the T200. This action will take several seconds, as the servo-drive power section is disabled, the T200 put in a special data reception mode, and the data downloaded. During the period of download, a special icon will appear, which indicates that the user must wait until the action is completed. The **Close** button should be clicked to progress to the next dialog box when download is complete.

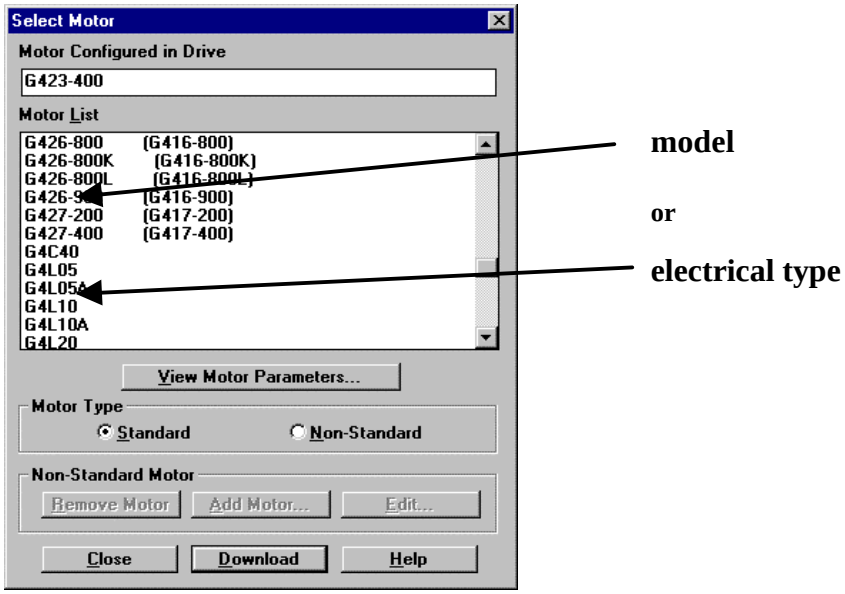

Figure 7.32: Select Motor Dialog Box

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b) Non Standard Motor Selection

Non-standard motor entry should only be necessary when using MOOG's older 30X series motors, when using MOOG custom designed motors, or when configuring the T200 to function with a motor from another manufacturer. For non-standard motors, the parameters necessary for drive interfacing must be known (or determined) by the user.

To view or edit non-standard motor data, the user should first click on the **Non-Standard** field of the **Motor Type** section of the Select Motor dialog. The **Motor List** will automatically change to display all 'known' non-standard motors, i.e. 30X series, MOOG custom designed motors and previously edited non-MOOG motors. These 'known' motors can be selected and their parameters be viewed and downloaded in the same way as the standard MOOG motors.

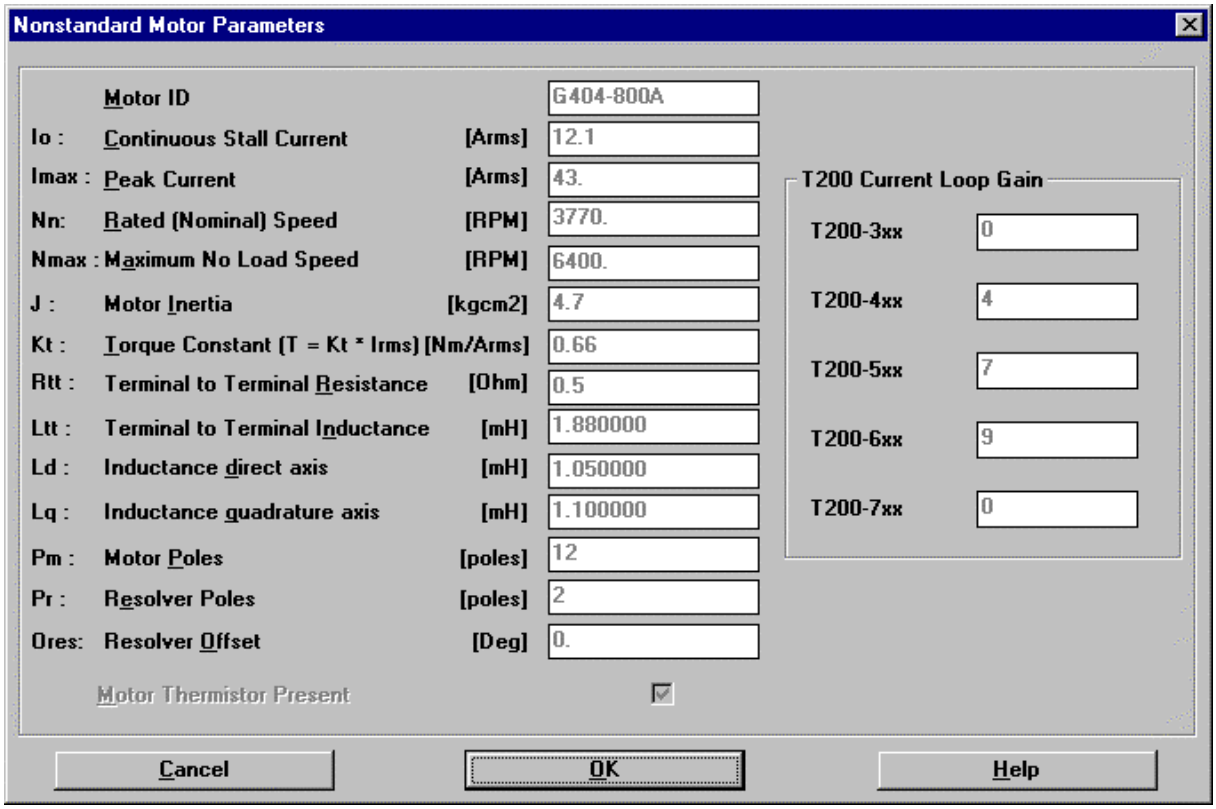
Nonstandard Motor Parameters
Motor ID
G404-800A
Io : Continuous Stall Current [Arms] 12.1
Imax : Peak Current [Arms] 43.
Nn: Rated (Nominal) Speed [RPM] 3770.
Nmax : Maximum No Load Speed [RPM] 6400.
J : Motor Inertia [kgcm2] 4.7
Kt : Torque Constant (T = Kt * Irms) [Nm/Arms] 0.66
Rtt : Terminal to Terminal Resistance [Ohm] 0.5
Ltt : Terminal to Terminal Inductance [mH] 1.880000
Ld : Inductance direct axis [mH] 1.050000
Lq : Inductance quadrature axis [mH] 1.100000
Pm : Motor Poles [poles] 12
Pr : Resolver Poles [poles] 2
Ores: Resolver Offset [Deg] 0.
Motor Thermistor Present
T200 Current Loop Gain
T200-3xx 0
T200-4xx 4
T200-5xx 7
T200-6xx 9
T200-7xx 0
Cancel
OK
Help

Figure 7.33: Nonstandard Motor Parameters Dialog Box

Parameter information for non-standard motors may be added to a non-standard motor database by selecting the **Add Motor** button. Information may also be removed by selecting the motor and then clicking on the **Remove Motor** button. Parameters may be edited by the user by selecting the **Edit** button.

CAUTION: Entry of invalid non-standard motor data may cause non-optimal performance of the motor, or in an extreme case, damage to the user's machine.

If the non-standard motor is manufactured by MOOG, the non-standard motor data set is available from MOOG, and the user may already possess this data. However the **T200 Current Loop Gains** may not be known by the user. The user should consult MOOG Applications Engineering if he does not know the value of all of the motor parameters required above.

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NOTE - G40X series MOOG motors usually have an equivalent standard MOOG motor. The G40X motors and their equivalent standard motors have the same electrical parameters, though may differ in mechanical configuration. The T200 only needs to be configured with the correct electrical parameters. Consult the MOOG sales outlet for information on the equivalent standard motor. If this equivalent is known, the standard motor may be entered instead of a non-standard motor.

NOTE - When the Motor Type is set to standard, the Remove Motor, Add Motor and Edit features are disabled.

7.10.1.3 Reference Source Selection

The servo-drive's reference source is chosen using the Reference Source Dialog Box shown below. Reference sources are explained in Section 6. Note that the reference rate limits are also outlined in that section.

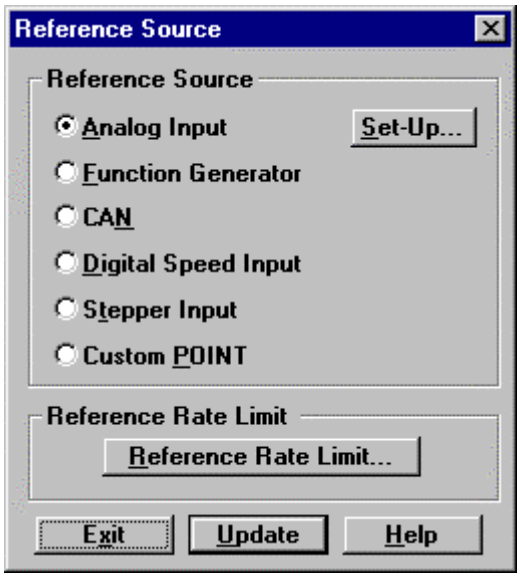

Figure 7.34: Reference Source Dialog Box

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a) Analog Input Reference

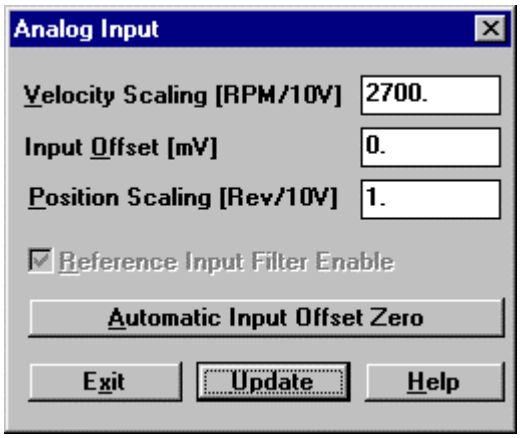

Figure 7.35: Analog Input Dialog Box

The **Analog Input** is a ±10V signal which is used as a command reference. When the Analog Input is being used as the reference source, several parameters must be set in the dialog box. Enter this dialog via **Set-up** from the Reference Source dialog.

Velocity Scaling: The Velocity Scaling is defined as the commanded motor speed (in RPM) when the analog input value is +10V. The maximum desired motor velocity is usually entered in this field, so that the motor will rotate at this speed when the analog input voltage is +10V. This is always a positive number.

Input Offset: The Input Offset is used to adjust the input voltage offset. It is entered in Millivolts (mV). The default value in the **Input Offset** field is zero.

Position Scaling: If the T200 is operated in Position Mode, then the analog reference can be used as a positioncommand. The Position Scaling can be used to set the number of motor shaft revolutions corresponding to 10V.

Automatic Input Offset Zero: The T200 automatically calculates the analog offset voltage upon clicking this button. It assumes that the present command voltage corresponds to zero torque, velocity command or to the 'home' position.

NOTE - The operation of the Analog I/O is specified in detail in Section 6.4.

b) Function Generator Reference

WinDrive compatible servo-drives feature a software based function generator that is used as the reference source for drive tuning. Enter this dialog via **Set-up** from the Reference Source dialog.

Speed Amplitude: If the **Speed Offset** was set to 0, then the **Speed Amplitude** would set an equal magnitude of the speed reference command in the clockwise and counter-clockwise direction. The Speed Amplitude must be a positive number. It is specified in units of RPM.

Speed Offset: Used to bias the commanded velocity. It can be positive or negative. The Speed Offset is specified in units of RPM.

Torque Amplitude: This is specified in units of Nm or lb-in. If the Torque Offset was set to 0, then the Torque Amplitude would set equal magnitude of the torque command in the clockwise and counter-clockwise direction. The Torque Amplitude must be a positive number.

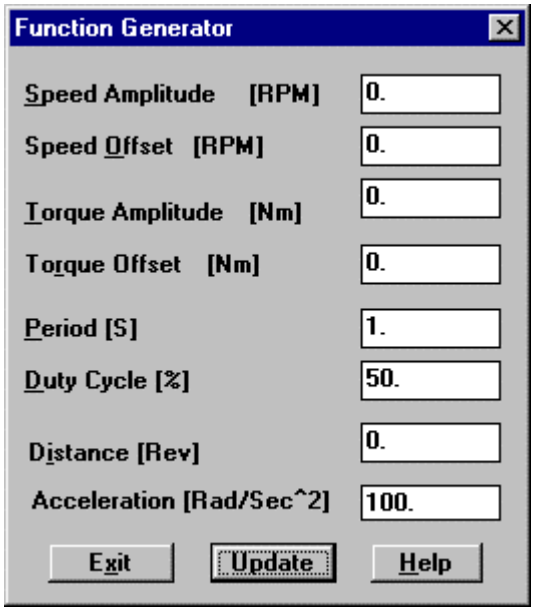

Figure 7.36: Function Generator Dialog Box

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Torque Offset: The **Torque Offset** is used to bias the torque of the motor in one direction of rotation. It can be positive or negative. It is specified in units of Nm or lb-in.

Period: The **Period** determines the time taken for one cycle of operation for one cycle of the Function Generator. This is specified in seconds.

Duty Cycle: The **Duty Cycle** determines the length of time the Speed (Velocity Mode) or Torque Amplitude (Torque Mode) is of a positive polarity and is expressed as a percentage of the **Period**. For the remainder of this time, the Speed or Torque Amplitude is negative. A Duty Cycle of 50% means that Speed or Torque Amplitude have positive and negative polarity for the same length of time during one Function Generator **Period**.

Distance: The **Distance** is used when the T200 is in Position Mode. The T200 generates an S-shaped position profile, with maximum acceleration, speed and end position determined by the Function Generator's **Acceleration**, **Speed Amplitude** and **Distance** (in revolutions) parameters, respectively.

Acceleration: The **Acceleration** is used by the Profile Generator in Position Mode as described under the Distance parameter and specified in radiants / second^2.

NOTE - The operation of the Function Generator is specified in detail in Section 6.5.

c) CAN Reference

The Controller Area Network (CAN) interface mode is described in Section 9. Enter this dialog via **Set-up** from the Reference Source dialog.

Mode: The Mode field selects between CAN Profile Mode and CAN Interpolation Mode.

CAN Baud Rate: The user can choose the baud rate from the following selection: 1000kBaud, 800kBaud, 666kBaud, 500kBaud, 400kBaud, 320kBaud, 250kBaud, 200kBaud, 160kBaud, 125kBaud, 100kBaud, 80kBaud, 50kBaud, 40kBaud, 20kBaud, 10kBaud, 5kBaud.

CAN Communication Cycle Period: The CAN cycle period (time between SYNC messages) is entered via this window. Units are microseconds.

CAN Command Window: The time from the SYNC message arrival to the time when the T200 checks for COMMAND messages is called the Command Window. Units are microseconds.

CAN Actual Window: The time from the transmission of the ACTUAL message until the next SYNC message is called the Actual Window. Units are microseconds.

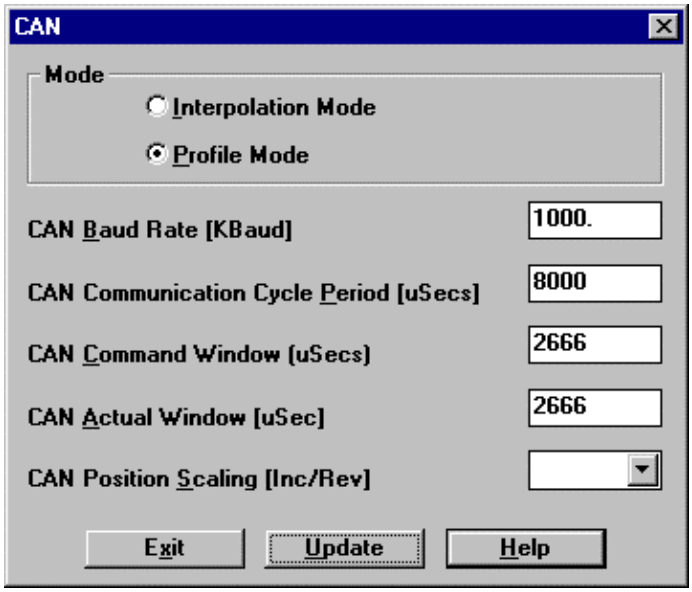

Figure 7.37: CAN Dialog Box

CAN Position Scaling: The user can select 16384, 8192 or 4096 CAN increments per motor shaft revolution. This scaling is applied to all CAN position variables.

NOTE - The operation of the CAN Interface is specified in detail in other MOOG documents. These can be provided by the MOOG sales outlets listed in Section 11 on request.

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d) Digital Speed Input Reference

The Digital Speed Input functionality is described in Section 6. The reference speeds corresponding to the state of the 2 digital inputs are specified in units of RPM. Enter this dialog via **Set-up** from the Reference Source dialog.

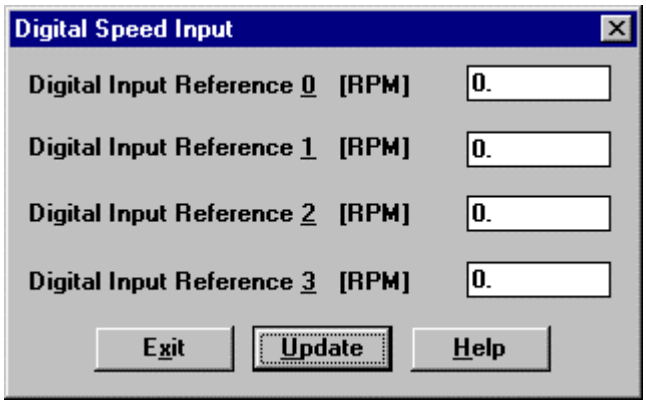

Figure 7.38: Digital Speed Input Dialog Box

PROG_ SPRD_1 Status	PROG_ SPRD_0 Status	Speed Reference Used
0	0	Digital Input Reference 0
0	1	Digital Input Reference 1
1	0	Digital Input Reference 2
1	1	Digital Input Reference 3

Table 7.3: Digital Input Speed Programming

e) Stepper Input Reference

The **Stepper Input** Position Reference is set-up using the dialog shown below. It can be entered by clicking the **Set-up** button in the Reference Source dialog.

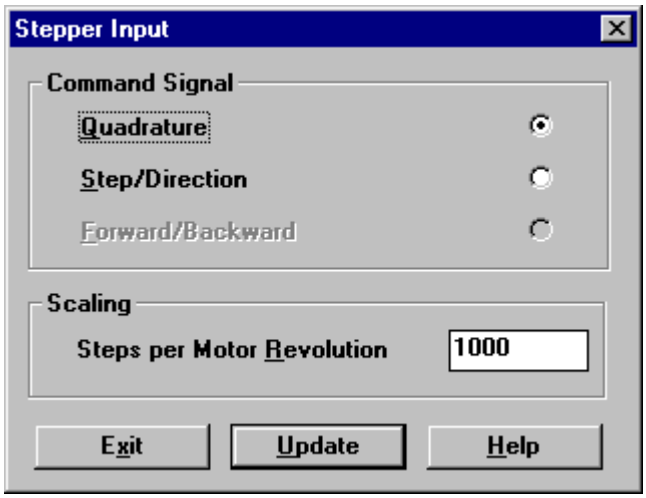

Figure 7.39: Stepper Input Dialog Box

Two formats for the protocol are detailed in Section 6. One of the two can be selected by choosing one of the **Quadrature** or **Step/Direction** radio buttons in the **Command-Signal** field.

Scaling is set by the number of stepper pulses per revolution. Note that in Quadrature mode, there is an effective resolution increase by a factor of 4 over other modes because each pulse edge can be used as a position increment. For example if the **Steps per Motor Revolution** field is set at 10, the number of discrete position steps per revolution will correspond to 40 if a **Quadrature** type **Command Signal** was selected. However only 10 such steps will exist if the **Step/Direction** mode is chosen.

NOTE - The operation of the stepper interface is specified in detail in Section 6.11.

f) Custom POINT Reference

If integral motion control is used as a command source, the **Custom POINT** option is selected. This option is only available if the T200 embedded software version is 'Pn', where n is the software revision. Use of this software is covered in the 'T200-POINT User's Manual' MOOG Part Number C09661-001.

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7.10.1.4 Reference Rate Limit Set-up

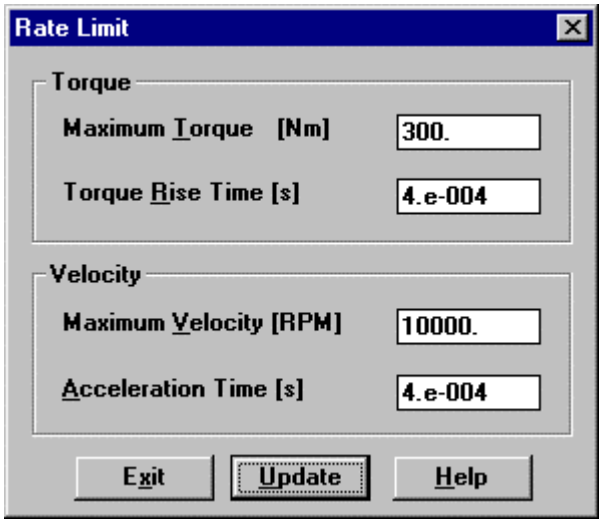

Figure 7.40: Rate Limit Dialog Box

The Rate Limit Dialog box allows limiting of the rate of change of the velocity and torque commands that are applied to the drive. Enter this dialog via **Set-up** from the Reference Source dialog. Note that this functionality has been outlined in Section 4.

When in Torque Mode, the T200 torque command is allowed to climb to the **Maximum Torque** (specified in Nm) in a time **Torque Rise Time** (specified in seconds). If the T200 is in velocity mode, then the velocity command is allowed to climb to the **Maximum Velocity** (specified in RPM) in a time given by the **Acceleration Time** (specified in seconds).

NOTE - The operation of the reference rate limiting is specified in detail in Sections 6.6.1 and 6.6.2.

NOTE – There is a lower limit to the rate limit that can be configured, for both Velocity and Torque Modes. If the user sets the rate limiting at too low a value (corresponding to seconds to reach peak torque or nominal motor velocity), then the T200 will impose a minimum rate limit.

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7.10.1.5 Normal and Reduced Power (Automatic and Manual Mode) Limits Set-up

The Limits Dialog box allows the user to specify operating limits for both torque and velocity to the servo-drive to ensure proper tuning and safe operation of the system (see Section 6 for a description of functionality). Automatic, or normal mode operation is used after a servo-drive has been tuned and configured successfully and the values for both the torque and velocity limits are set higher than those for manual mode.

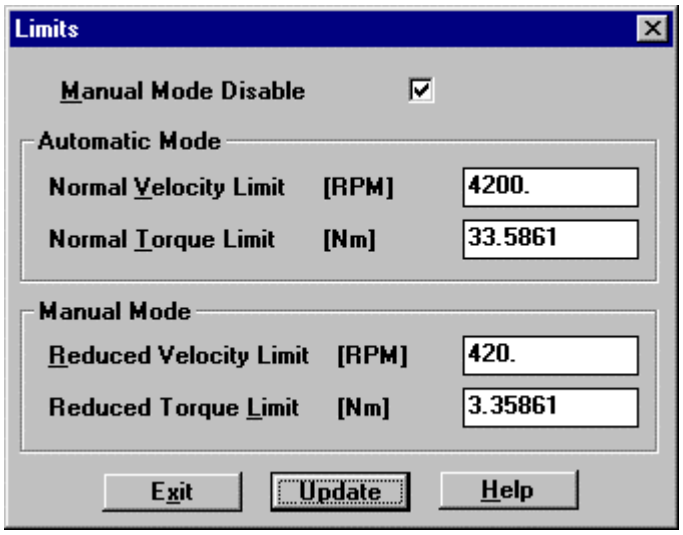

Figure 7.41: Limits Dialog Box

Manual Mode Disable: The user can disable Manual Mode if he does not wish to wire up the Manual/Automatic digital input (connector J1, pin #7). The **Manual Mode Disable** box should be ticked to disable the T200 from entering Manual Mode.

Automatic Mode Parameters

Normal Velocity Limit: The velocity command limit is specified in RPM.

Normal Torque Limit: The torque command limit is specified in Nm or lb-in.

Manual Mode Parameters

Reduced Velocity Limit: The velocity command limit is specified in RPM.

Reduced Torque Limit: The torque command limit is specified in Nm or lb-in.

WARNING: The user should only consider disabling of Manual Mode when he is assured that the T200 is properly configured and no dangers to equipment or personnel are present e.g. if the machine safety cage is open then disabling of Manual Mode is not advised.

7.10.1.6 Hardware Limit Switches Set-up

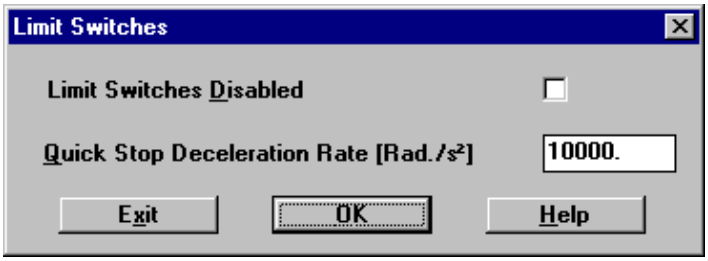

Figure 7.42: Limit Switches Dialog Box

Clockwise and Counter-Clockwise hardware Limit Switches connected to the drive system can be disabled from the Limit Switches Dialog box. The **Limit Switches Disabled** checkbox should be ticked to disable the hardware Limit Switches.

Velocity Mode: If a Limit Switch is activated when the T200 is in Velocity Mode, the motor is brought to a Servo Stop by the drive, and further movement in the direction of that Limit Switch is not allowed. The **Quick Stop Deceleration Rate** at which the motor stops is determined by the user, in units of rad/s^2. Movement in the other direction is still possible.

Torque Mode: If the Limit Switch is activated when the T200 is in Torque Mode, then the torque command will be clamped to zero in that direction. Torque generation in the other direction is still possible.

CAUTION - The safety Limit Switches of the machine must be connected through hardware limit circuits such that the drive is hardware disabled if a limit switch is activated.

A comprehensive explanation of the Limit Switch functionality can be found in Section 6.4.5 Limit Switch Function.

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7.10.1.7 Drive Tuning

This dialog enables the user to select the Control Mode for the drive, set up the Tuning Gains as well as enter additional tuning related dialogs. Refer to section 7.11.1 Control Mode Selection.

7.10.1.8 Encoder Simulation (ESM)

The functionality of an incremental rotary encoder may be emulated with Encoder Simulation software. Feedback information is read from the motor resolver where it is interpreted by a software/hardware model (depending on ESM mode) and converted into Encoder Simulation information.

The user must enter a value for the **Number of Lines per Revolution**. Two modes of Encoder Simulation are available, **High Bandwith** and **Low Bandwith**.

1. **High Bandwidth ('ESM3'):** This is recommended for use when the T200 is placed in Torque Mode. This uses an analog hardware solution for the Encoder Simulation, but only values of 128, 256, 512 or 1024 may be used for the **Number of Lines per Revolution**. A position feedback bandwidth of between 800 and 1000 Hz is available when **High Bandwidth** mode is used.
2. **Low Bandwidth (ESM1):** This is recommended for use when the T200 is placed in Velocity Mode. Any other even number between 128 and 8192 entered for the **Number of Lines per Revolution** will result in **Low Bandwidth** operation. A hybrid of software and hardware, the feedback bandwidth of **Low Bandwidth** mode is limited to 400 Hz.

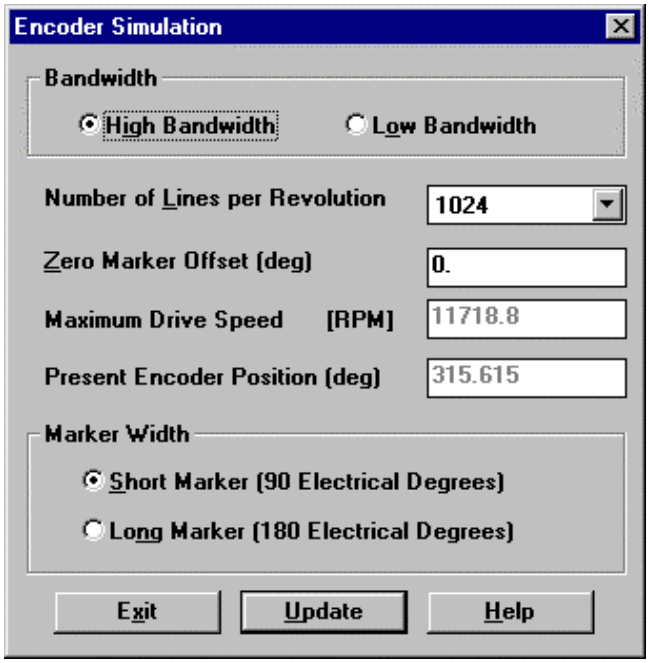

Figure 7.43: Encoder Simulation Dialog Box

The user may determine the **Zero Marker Offset** in mechanical motor shaft degrees of the zero marker of the Encoder Simulation output, with respect to the motor's own resolver position sensor natural zero position. Both the **Maximum Drive Speed** and **Present Encoder Position** fields are determined by the software and system parameters. The **Marker Width** options are selectable from **Short Marker (90 Electrical Degrees)** and **Long Marker (180 Electrical Degrees)**.

7.10.1.9 Regen (Brake) Resistor Configuration

The Regen Resistor Configuration dialog box allows the user to set up the selected regen (regeneration) resistor. The correct parameters for the regen resistor are essential for a proper operation of the Regen Exceeded functionality as described in section 6.8.5.

External Regen Resistor Connected: Enables the Regen Exceeded functionality which indicates that the maximum continuous power of the external regen resistor is exceeded. This box needs to be ticked if an external regen resistor is connected to the T200.

Disable Drive if Regen Exceeded: If this box is ticked the T200 will perform a Quick Stop and disable as soon as the maximum continuous regen power is exceeded. Otherwise only regen exceeded will be indicated but no Quick Stop is performed. For further description see section 6.8.5.

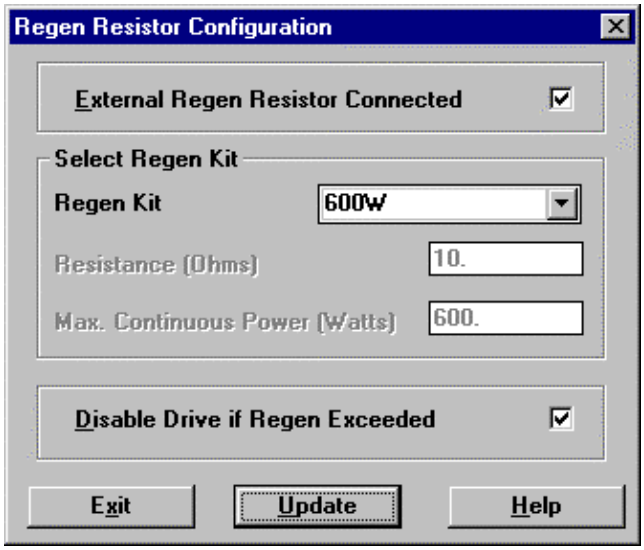

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Figure 7.44: Regen Resistor Configuration Dialog Box

Select Regen Kit: Allows the selection of the regen kit used in the application. The selection is based on the maximum continuous power of the regen resistor kit. Data of a regen resistor not supplied by MOOG can be set up under “Other”. This option allows the setting of the resistor value and the maximum continuous power of the resistor.

WARNING: It is the user's responsibility to ensure that the correct regen configuration is set up. The Regen Exceeded functionality is the only protective mechanism which indicates to the user that the continuous regen power for the regen resistor is exceeded. Excessive regen power will thermally damage the regen resistor. Dependent on the material of the regen resistor the resistor may catch fire.

7.10.1.10 Saving a Configuration to Non-Volatile Storage

On completion of the **Basic DriveSetup**, the completed tuning information is downloaded to drive EEPROM using the Save to EEPROM function. By clicking on the **Save** button, the parameters which have been set in the T200 volatile storage are transferred into non-volatile storage, and the T200 will be configured with these parameters the next time the T200 is powered-on or reset.

Figure 7.45: Save to EEPROM Dialog Box

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7.10.2 Torque Mode Operation

In Torque Mode, the input command reference is a current command to the power amplifier that drives the motor. The term Torque Mode is adopted because the motor produces a nearly linear torque per ampere of input current. The tuning of the inner current loops of WinDrive compatible servo-drives is pre-programmed during drive initialization, by selection of the motor model or the electrical type.

The Control Compensator should be set to Torque Mode, using the Tuning Dialog box (see Section 7.11.4.2 Control Mode). Offsets in the servo-drive and the user's torque analog command may be trimmed out using the offset adjustment methods available (see Section 7.10.1.3 Reference Source Selection, Analog Input, Input Offset). The desired Automatic and Manual Mode Torque Limit should be entered in the Limits Dialog Box (See Section 7.10.1.5 Normal and Reduced Power (Automatic and Manual Mode) Limits Set-up).

The Encoder Simulation should also be set-up (see Section 7.10.1.8 Encoder Simulation (ESM)).

Parameters should be saved to non-volatile storage once configuration is complete (see Section 7.10.1.10 Saving a Configuration to Non-Volatile Storage).

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7.11 Control Loop Configuration and Tuning

This section describes how WinDrive allows easy configuration and monitoring access to T200 internal variables, to facilitate quick configuration of control loops and estimation of control loop gain values. The Auto Tuning feature is described as well.

NOTE: The user should review Section 6.6.2, Velocity Loop Tuning, before starting the tuning process.

7.11.1 Control Mode Selection

The user should choose the appropriate control mode for the application.

- The T200 provides selection of Torque, Velocity or Position Mode control configurations.
- Additionally, if the drive is configured in Velocity Mode, the T200 can switch between Velocity and Torque Mode under the control of the TRQ_VEL digital input. Mode switching is not possible if the user has selected any other mode besides Velocity.

Mode: The appropriate control mode is selectable by clicking on either the **Torque**, **Velocity** or **Position** button. The user is also informed of the present control mode of the T200.

Gains: The **Velocity Loop Gain, Integral Time Constant** and if enabled, the **Position Loop Gain, Position Loop Integral Gain, Velocity Feed Forward Gain and Torque Feed Forward Gain** can be set from the **Gains** menu. These items will be described in 7.11.4.1 Velocity Estimation, Velocity Loop Tuning and Section Position Loop Tuning.

While the **Tuning** dialog box is active, the Up and Down arrow keys on the keyboard or the arrows to the right of any tuning parameter field can be used to adjust the respective parameter up or down by 5% with each key or mouse button press. The **Automatic Update** check box within the **Combined Tuning** dialog box is checked to force changes made to any tuning parameter to be immediately sent to the T200.

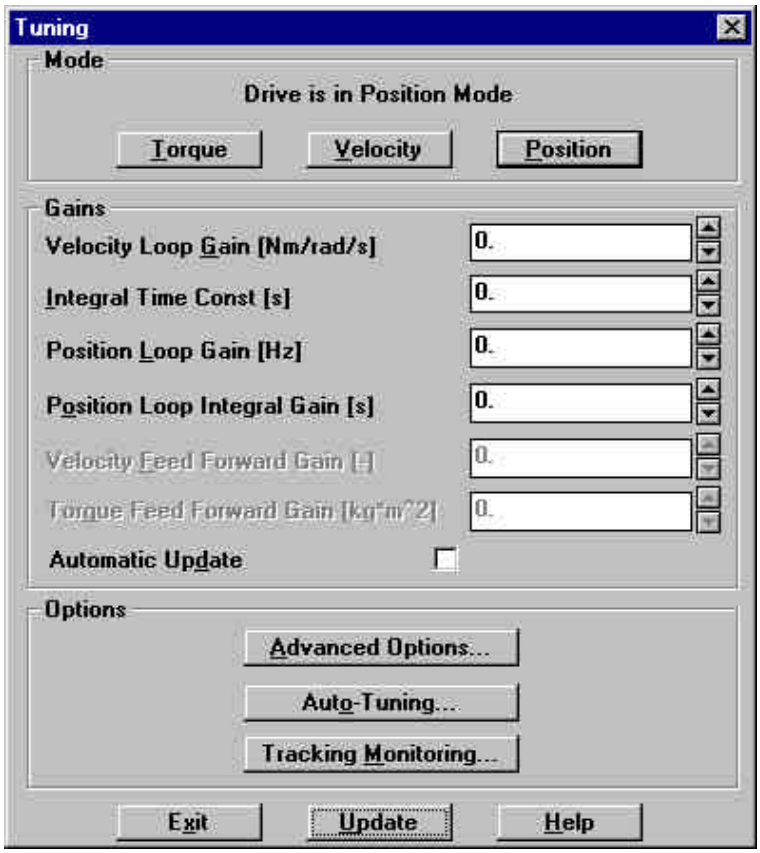

Figure 7.46: Tuning Dialog Box

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Options: **Advanced Options** for T200 control loops, **Auto-Tuning** and control loop **Tracking Monitoring** parameters can be accessed from the **Options** group. These features are described in Sections Advanced Options, Section Auto Tuning and Tracking respectively.

Update: This button is used to write the tuning parameter values shown in the dialog to the T200.

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7.11.2 Torque Mode Tuning

As mentioned earlier, tuning of the current loops is performed during drive initialization. Hence no parameter tuning is required in Torque Mode.

7.11.3 Velocity Loop Tuning

After completing drive configuration per Section Drive Set-up the user must tune the velocity loop to optimise velocity loop performance. This section provides a recommended velocity mode standard tuning procedure for use with WinDrive. Note that a generic velocity loop tuning procedure (WinDrive or the Hand Held Terminal interfaces can be used with this procedure) is given in Section 6.6.2. The procedure should be followed in the sequence listed, noting all warnings appropriately. Velocity Mode should be selected from the **Tuning** dialog box (see Section Control Mode Selection). Tuning can be carried out in Reduced Power mode (Manual Mode) where there is a concern about safety.

7.11.3.1 Combined Tuning Window

The **Drive/Set-up/Combined Tuning** main screen configuration provides a convenient way of monitoring T200 variables whilst setting loop gains. The WinDrive Data Logger and the **Combined Tuning** dialog are immediately visible in this mode. The Data Logger may be immediately re-triggered once the control loop gain is suitably adjusted. The **Function Generator** parameters may also be adjusted in the **Combined Tuning** dialog.

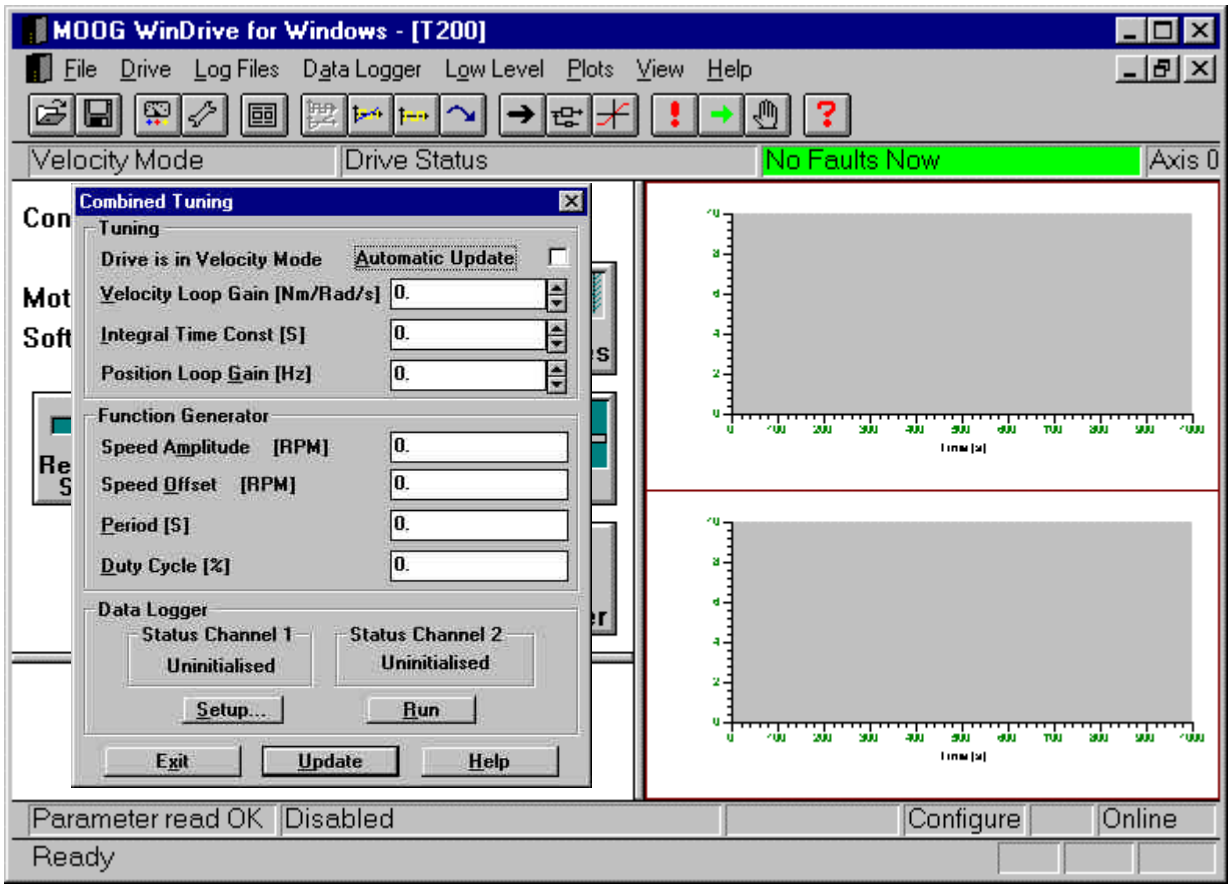

Figure 7.47: Combined Tuning Main Screen View

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It is recommended to monitor the Torque Demand and the Actual Velocity variables during Velocity Loop tuning. The Data Logger will be set up by default to monitor these variables. See Section 7.9.1 Data Logger for a description of how to set up these variables as the logged data set.

The servo-drive should be enabled first through the External Enable digital input, and then software enabled using the **F3** key, Floating Toolbar or Main Tool Bar (Function Generator initialised as detailed above).

While the **Combined Tuning** dialog box is active, the Up and Down arrow keys on the keyboard or the arrows to the right of any tuning parameter field can be used to adjust the respective parameter up or down by 5% with each key or mouse button press. The **Automatic Update** check box within the **Combined Tuning** dialog box should be checked to force changes made to any tuning parameter to be immediately sent to the servo-drive. If the **Automatic Update** check box is not ticked, parameters in the drive can be updated by clicking the **Update** button.

A full description of the manual tuning procedure is given in Section 6. This should be reviewed before starting to tune with WinDrive.

7.11.4 Advanced Options

This section details the use of the **Advanced Options** for tuning, found in the **Options** of the **Tuning** dialog and **Drive/Set-up/Advanced Options** Menu.

Upon selecting the **Advanced Options**, the Advanced Options dialog box appears. It contains two sections, **Velocity Estimation** and **Control Mode**.

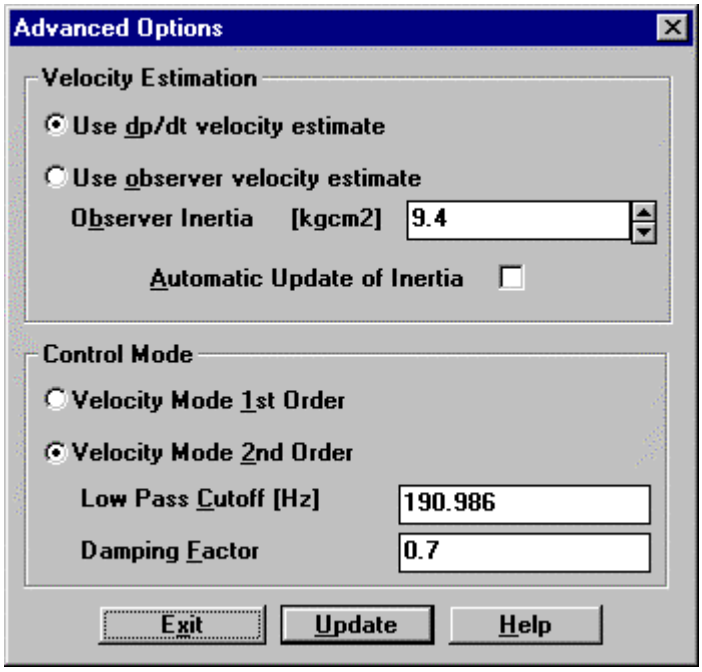

Figure 7.48: Advanced Options Dialog Box

7.11.4.1 Velocity Estimation

The default value for this option is **Use dp/dt velocity estimate**, where the software estimates the velocity of the motor from position and time data. A more accurate value for the motor velocity may be obtained by selecting the option **Use observer velocity estimate**. This system uses a software simulation of the servo-drive and motor configuration to determine a more accurate motor velocity signal. The user can adjust this model by tuning of the **Observer Inertia**

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parameter. Tuning of the software model for the user applications is described in Section 6.6.2. Note that the Data Logger can be used to record Torque Demand and Observer Position Error, in a convenient way during observer tuning.

While the **Advanced Options** dialog box is active, the Up and Down arrow keys on the keyboard or the arrows to the right of the **Observer Inertia** field can be used to adjust the parameter value up or down by 5% with each key or mouse button press. The **Automatic Update** check box should be checked to force changes made to the **Observer Inertia** field to be immediately sent to the servo-drive. If the **Automatic Update** check box is not ticked, the parameter value in the drive can be updated by clicking the **Update** button.

7.11.4.2 Control Mode

The torque command, which is generated in Velocity Mode, is filtered using an internal digital filter. It may be necessary in some applications to optimise this digital filtering.

Velocity Mode 1st Order: A first order filter is used whose only setting is its **Low Pass Cutoff** filter frequency in Hz.

Velocity Mode 2nd Order: A second order filter is used which needs a **Low Pass Cutoff** filter frequency in Hz and a **Damping Factor** to be specified.

NOTE: The **Low Pass Cut-off** and the **Damping Factor** are set to safe values which depend upon the motor model selected. Consequently the motor should be configured before changing these values.

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7.11.5 Auto Tuning (Velocity Loop Only)

Auto Tuning of T200 Velocity Loop Gain parameters and the Velocity Observer is only available through WinDrive. If quick tuning of a T200 is required by the user, WinDrive's Auto Tuning feature can be used to determine the values of both the velocity loop gain and the integral time constant terms. Auto Tuning can be selected from the **Drive/Set-up** Menu or via the Auto-Tuning button in the Tuning dialog.

A software generated excitation signal is fed to the motor by WinDrive and the response is recorded. Using the response information, values are determined for Velocity Loop Gain (P) and Integral Time Constant (I). It should be noted that Auto Tuning defined values for P and I are not optimum values. The velocity loop bandwidth (a measure of the quickness of response of the velocity loop to changes in the velocity command) that is achieved using the Auto Tuner is set to a default value of 50Hz.

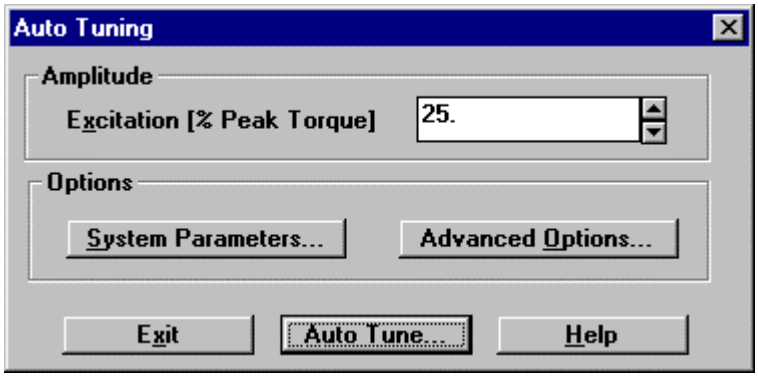

Figure 7.49: Auto Tuning Dialog Box

Excitation Amplitude: The user can set the level of excitation torque as a percentage of the peak torque available from the T200 - motor combination. It is recommended that this level is set as high as possible so that as large a movement as possible is created without damaging the user machine.

System Parameters: This will allow for view of system parameters that were identified during Auto Tuning (load inertia etc.).

Advanced Options: This sub-dialog allows the user to set advanced tuning features and view the calculated response of the Auto Tuning process.

Auto Tune: Clicking on this button starts the Auto Tune process.

CAUTION: The Auto Tune algorithm causes the motor to be excited with a high frequency torque. This is typical of most tuning algorithms. The machine should be capable of withstanding such an excitation torque, which contains a significant number of torque steps.

NOTE
The **ENABLE** digital input must be active to allow the T200 to apply torque to the load and measure the response. The user should ensure that he has hardware-enabled the T200 via the DRV-ENABLE digital input.
The **BRK-IP** digital input must also be active to allow the T200 to release the brake during the Auto Tuning process. Note that the WinDrive interface will release the brake automatically at the appropriately times, when it expects that movement is required to estimate the load. The user should ensure that he has hardware-released the brake of the motor (if a brake is present) via the BRK_IP digital input.

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7.11.5.1 Auto Tuning System Parameters

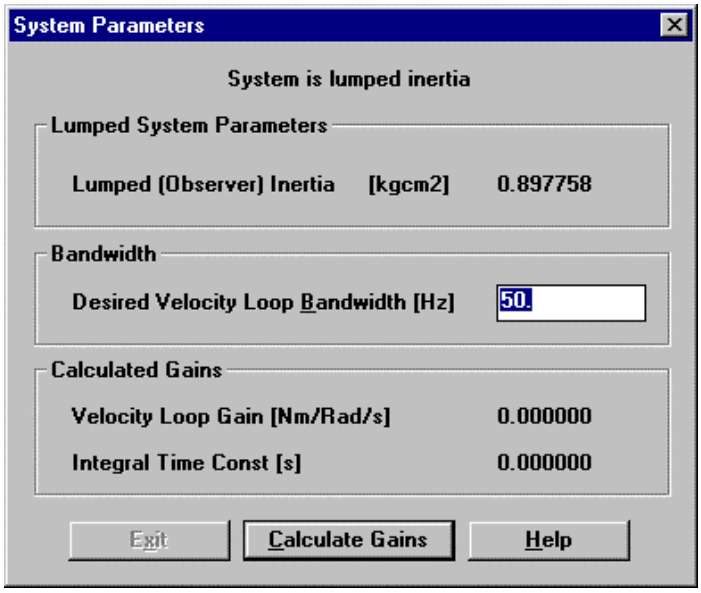

Figure 7.50: Auto Tuning System Parameters Dialog Box

The System Parameters dialog provides a means of viewing and setting various Auto Tune parameters and results:

The user is informed if the load system is resonant. If the system is resonant then there is some flexibility in the coupling of the load to the motor. If the system is found to be significantly resonant and the loops cannot be tuned safely by the Auto Tuner, then the Auto Tuning process will be aborted and the user be informed of that.

Lumped System Parameters: When the Auto Tuning process has run, the **Lumped (Observer) Inertia** value in $kgcm^2$ indicates the value of the motor and load inertia reflected to the motor side of any gearbox or coupling mechanism.

Bandwidth: The default **Desired Velocity Loop Bandwidth** is 50Hz, which is sufficient for most servo-drive applications.

However if additional stiffness or disturbance rejection is required, then the user can increase the **Desired Velocity Loop Bandwidth**.

Calculated Gains: The P and I gains suggested by the Auto Tuner are displayed when the **Calculate Gains** button is clicked. Note that if the **Desired Velocity Loop Bandwidth** is set to a value different from the default, the **Calculate Gains** button should be re-clicked.

7.11.5.2 Auto Tuning Advanced Options

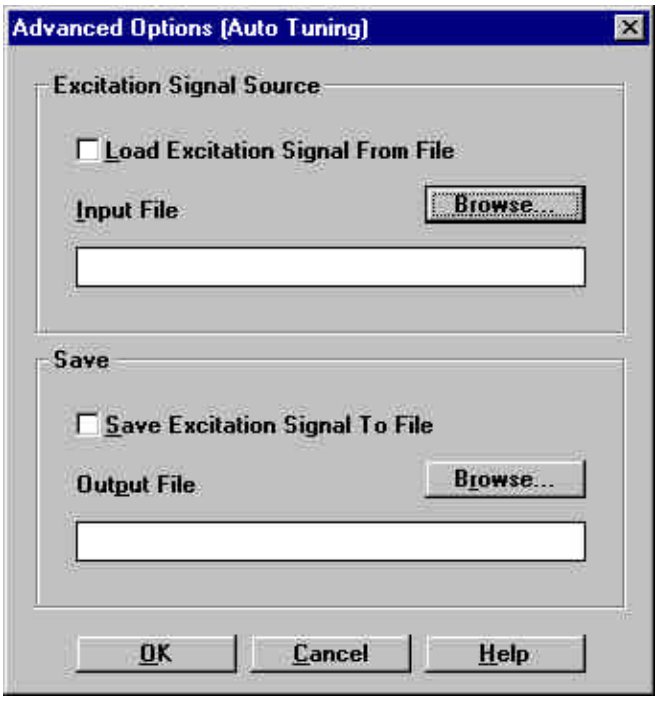

Figure 7.51: Advanced Options (Auto Tuning) Dialog Box

The Advanced Options (Auto Tuning) dialog enables the user to load or save an excitation signal from / to a file, respectively.

Load Excitation Signal From File: This checkbox has to be ticked when an excitation signal is to be downloaded from an **Input File** to the T200.

Save Excitation Signal To File: This checkbox has to be checked when an excitation signal is to be uploaded from the T200 to an **Output File**.

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7.11.6 Tracking Monitoring

The **Tracking Monitoring** dialog box is available from the **Tuning** dialog box. This dialog is used to set warning thresholds, such that if these thresholds are exceeded, the T200 will flag the warnings to users via the 7-segment display, and through feedback via the CAN channel.

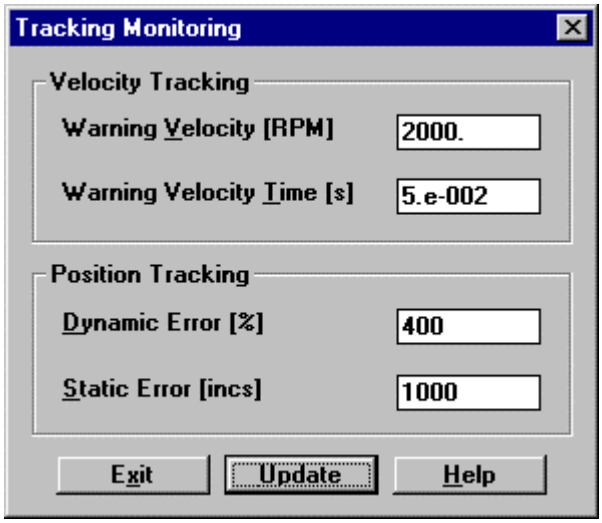

Figure 7.52: Tracking Monitoring Dialog Box

Velocity Tracking: The Velocity Error is the difference between the velocity command and the Actual Velocity. The Velocity Following Error warning will be set if the absolute value of the error velocity exceeds the **Warning Velocity** for the **Warning Velocity Time**.

Position Tracking: The Position Error is the difference between the position command and the Actual Position. The Position Following Error warning will be set

1. if the absolute value of the position error exceeds a quantity equal to

   Actual Velocity • **Dynamic Error**/(100 • **Position Loop Gain**).

   This quantity is the expected Position Error of a position loop with no Velocity Feedforward compensation, multiplied by the **Dynamic Error** factor.

   or,

2. if the absolute value of the Position Error exceeds the **Static Error** (expressed as position increments - see Section 7.10.1.3 Reference Source Selection, CAN Reference Source, CAN Position Scaling).

7.11.7 Position Loop Tuning

After completing drive configuration as per Section Drive Set-up, the user must tune the position loop to optimize position loop tracking and disturbance rejection performance. This section provides a recommended Position Mode tuning procedure for use with WinDrive. Note that a generic position loop tuning procedure (WinDrive or the Hand Held Terminal interfaces can be used with this procedure) is given in Section 6.6.3. The procedure should be followed in the sequence listed, noting all warnings appropriately. **Position Mode** should be selected from the **Tuning** dialog box (see Section Control Mode Selection). Again tuning can be carried out in Reduced Power Mode (Manual Mode) where there is a concern about safety.

The recommended practise for tuning the Position Loop is:

1. First tune the Velocity Loop by following Section Velocity Loop Tuning. The Velocity Observer can also be used to increase Velocity Loop Gains, by following Section 7.11.4.1 Velocity Estimation. Note that the Auto Tuner can be used to adjust the Velocity Loop Gains.
2. Change the control mode to Position Mode (see Section Control Mode Selection). Now tune the Position Loop Gain using the procedure described in Section 6.6.3.

Tuning of the Position Loop Gain is facilitated by use of the Data Logger (see Section Data Logger) and the T200's built-in Function Generator. Set the Data Logger to record **Reference Velocity** on Channel 1 and **Error Position Low** on Channel 2. Set the **Reference Source** to the **Function Generator** with appropriate **Distance**, **Acceleration**, **Speed Amplitude** and **Period** parameters.

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7.12 Incremental Encoder Input Configuration

The T200 Incremental Encoder input can be set-up via WinDrive. A description of the incremental encoder input is given in Section 6.10.

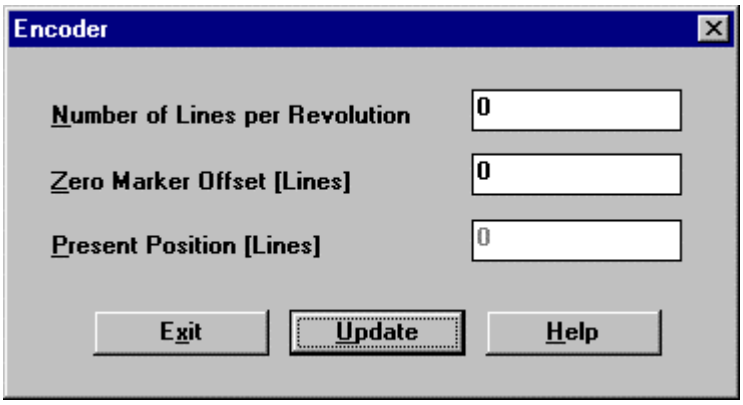

Figure 7.53: Encoder Dialog Box

Number of Lines per Revolution: The user sets this input to scale the encoder. The encoder input is used in Stepper Mode and POINT Mode. The motor cannot be commutated with the incremental encoder. The **Number of Lines per Revolution** is usually available from the encoder nameplate.

Zero Marker Offset (Lines): The rotational offset of the Incremental Encoder position is set by the user via this parameter. It is scaled in encoder lines.

Present Position (Lines): The present encoder position may be read using this display. Pressing the **Update** button updates the value displayed for **Present Position**. Note that the **Present Position** cannot be set by the user, since it is the output of a hardware module.

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7.13 Equipment And Personal Safety

WinDrive contains several functions to ensure equipment and personal safety.

7.13.1 Manual Mode / Automatic Mode

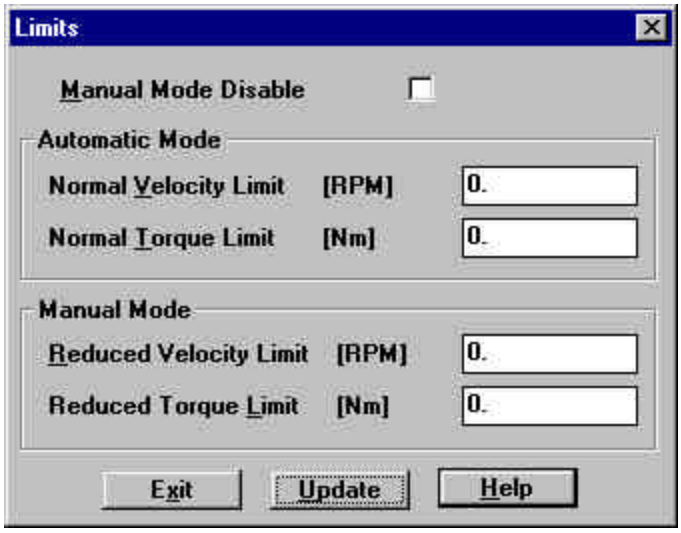

Figure 7.54: Limits Dialog Box

Manual and Automatic operating modes are set from the Limits Dialog box. Values are entered for both the Manual and Automatic Mode limits for Torque and Velocity. Manual Mode limits are always set below those for Automatic Mode resulting in lower Velocity or Torque operation than in Automatic (normal) Mode.

7.13.2 IT Thermal Limits

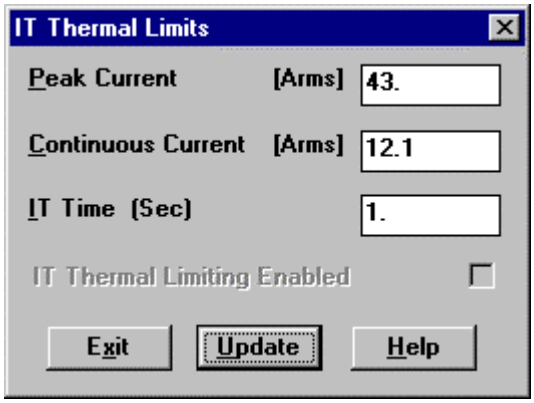

Figure 7.55: IT Thermal Limits Dialog Box

The IT (current time) Limits Dialog box is opened under the **Drive/Set-up/IT Thermal Limits** menu. Three limits may be set here, the **Peak Current**, the **Continuous Current** and the **IT Time** (peak current time) with **IT Time** being the maximum time **Peak current** is allowed for. The IT Thermal Limits may be defined as those of the motor - servo-drive configuration. To maintain equipment safety, all three values should be set to lower values than those corresponding to the rated peak current, the continuous current and the peak current time of the connected servomotor or servocontroller, whichever features the smaller rating.

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7.14 Drive Disabling

The drive may be disabled at any time through several means. In case of emergency **F2** may be pressed, the **Stop** Icon clicked or **Quick Stop** selected from the Drive Menu to perform a Quick Stop.

The drive may be disabled by pressing the **F4** key, clicking the relevant icon on the Floating Toolbar or selecting **Disable** from the Drive Menu.

CAUTION: The user should ensure that sufficient means exist to immediately disable the T200 through hardware means in the event of a communications or other software malfunction. This may be accomplished by switching the ENABLE digital input of the T200 with the main machine safety switch (Red Emergency Button).

CAUTION: The user should be aware of any potential hazard for personnel or equipment when disabling / Quick Stopping a motor. On disable, torque is removed from the motor completely so that any vertical axis may fall down. Additionally, if the motor is fitted with an optional brake, this brake stays open (released) when the drive is disabled. On Quick Stop, the servo-controller generates a zero command, holding the motor in its current position, and a warning is issued informing the user that the drive has to be disabled before it can be re-enabled. Disabling the drive under these conditions will result in the same behaviour as described for "normal" disabling above. If the motor is fitted with an optional brake, the brake may be applied after commanding a Quick Stop. This causes the brake to be applied and the controller to be disabled so that the motor shaft is held at its present position.

7.15 Programmable Behaviour of Outputs

In certain applications it may be desirable to change the polarity of the System Ready Relay and / or the Thermal Limit Output. These are programmable in the Invert System Ready Relay / Thermal Limit Output dialog.

Figure 7.56: Invert System Ready Relay / Thermal Limit Output Dialog Box

Invert System Ready Relay Polarity: When the polarity of the System Ready Relay is not inverted, it will be closed if no fault or warning condition is present and open in case of a fault or warning being detected by the controller. Check the **Invert System Ready Relay Polarity** checkbox to invert the polarity of the System Ready Relay.

Invert Thermal Limit Output Polarity: When the polarity of the Thermal Limit Output is not inverted, it will be closed if no Foldback fault is present and open in case of a Foldback fault being detected by the controller. Check the **Invert Thermal Limit Output Polarity** checkbox to invert the polarity of the System Ready Relay.

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7.16 Brake Control

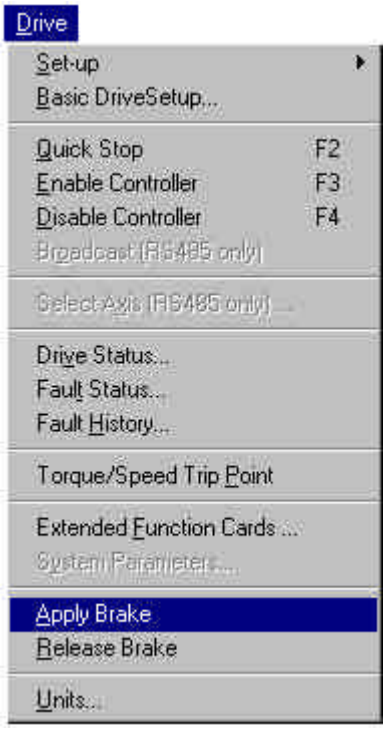

Figure 7.57: Apply Brake and Release Brake options on the Drive Menu

If an optional motor brake is fitted, this may be controlled from the **Drive Menu** with the **Apply Brake** and **Release Brake** commands.

7.17 Trouble Shooting

If WinDrive is unable to communicate with a servo-drive then the Graphical User Interface will issue a Communication Time-Out message. If this occurs, check the following:

- Check control and mains power to the drive.
- Check the serial communications cable for correct connection and wiring.
- Ensure that the drive has completed its boot-up cycle. WinDrive cannot communicate with the controller during drive boot-up. Allow approximately 20 seconds for the drive to boot up, before attempting communication with WinDrive.

If a time-out occurs during Log File upload / download or Save to EEPROM:

- The Serial Cable should be checked for correct connection.
- The value of the parameter "Timeout" under [[ComRs232] in the WinDrive.ini file may have to be increased for older PC's (default value: Timeout = 15000).

If other application problems are experienced when using WinDrive, the circumstances should be noted and MOOG Applications Engineering should be contacted.

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SECTION 8: HAND-HELD-TERMINAL INTERFACE

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8.1 Hand-Held-Terminal Interface ("Pod" Mode)

Configuration and Tuning of the T200 is possible using a Hand Held Terminal. This section details the use of this device.

WARNING - A User supplied hardware enable/disable switch wired so that the motor can be stopped quickly in a emergency must be provided at all times. Software enable/disable commands do not meet safety requirements and should never be used in lieu of a hardware circuit. Refer to European standard EN 60204-1 for requirements for Emergency Stop devices.

NOTE: Instruction on the use of the key sequences for hand held terminal, which allow changes to the T200 configuration and tuning should be restricted to technically qualified service and maintenance personnel only.

8.1.1 Establishing Serial Communications

For individual servo-drive communication the RS232 interface should be used. For multiple servo-drive applications, RS-485 multi-drop communications may be used. Connect the terminal to the T200 Series Servo-drive Serial Port Connector, see Figures 3.48 and 3.49.

Set the terminal serial interface parameters to 9600 baud, 1 stop bit, 8 data bits and no parity bits. There is no hardware handshaking. See Section 3.18.1 RS232 Connection for a description of the cabling required to connect PC Serial Port to the T200's J4 Serial Port. If terminal emulation software is used to configure the drive, the serial port of the PC should be connected to that of the T200.

8.1.2 Command Line Format

Commands used when programming via a terminal consist of a max. string length of five characters (one, two and three letter lengths are the most common). The first letter is common to a group of parameters and determines the action desired. The second, third, fourth and fifth letters determine parameters. Each of the following letters represents the initial character in a command string and indicates a functional group.

S: Set Parameter.

L: List Parameter.

O: Set/List Drive Option.

M: Drive Commands.

? : Enquire Commands.

Most parameters are entered as real numbers and are stored accurate to a very high precision. Numbers may be entered using decimal or scientific notation with up to six significant digits. Examples of valid numeric entries:

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> **-2.9 E -2 <CR>**

Enter numbers and press RETURN.

> **.029 <CR>**

> **0.029 <CR>**

> **203789 <CR>**

> **203.789e3 <CR>**

All string entries should be terminated by pressing the RETURN (<CR>) key.

If a command entry error is detected by the software, the following message will be displayed along with a prompt to re-enter:

Invalid

Command

>

All numeric parameters entered are compared against an acceptable range. If a parameter is outside this range, then the parameter remains at its present value.

CAUTION: In some case the T200 internal software truncates the entry, for safety or other internal reasons. Note that no message is displayed when entries are truncated. Thus, it is good practice to list all parameters using the appropriate [L] command after they have been entered.

All parameters may be set or listed when the motor is running. However, it is advisable to avoid large changes in parameters in this case.

Other features of the Hand Held Terminal interface are:

- The [CTRL H] key combination accesses a backspace function, allowing the deletion of incorrect command and parameter entries. When configuring the T200 via terminal emulation software, user entries may be deleted with the delete or backspace key.
- The [CTRL X] key combination will reset the T200 Series Servo-drive and has the same effect on servo-drive software as turning the power off then on.
- Commands entered are not case sensitive, e.g. [SP] and [sp] are both recognized.
- When (- more -) is displayed, press carriage return to continue.
- When current values of parameters are presented, they may be accepted by pressing RETURN (<CR>).
- The Q button may be pressed at any time to exit a parameter entry/ parameter list table.

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8.2 Servo-drive Initialization

NOTE - The installation and wiring described in Section 3 should be completed and verified before proceeding with servo-drive initialization.

CAUTION - The T200 Series Servo-drives with integrated power supply units have a built in soft start feature. An on-board interlock disallows enabling of the output inverter bridge until the soft start period has expired. This interlock signal is also supplied to the user via the power ready relay. The output of the power ready relay should be used in series with the enable interlock circuitry of any T200 servo-drive without integrated power supply that takes its d.c. bus power from the T200 with integrated power supply. Refer to Section 6.3.

WARNING - Perform all servo-drive initialization and configuration with the servo-drive hardware enable OFF and power ON. Failure to follow the correct procedure can result in machine damage and/or personal injury.

1. Power should be applied to the T200 Series Servo-drive.
2. The 7 segment display will illuminate all segments for a period of about 5 seconds. After this time a 'P' character will be displayed on the 7 segment display.
3. When the servo-drive has been properly initialised, then the appropriate fault, warning or operational status message will be displayed on the 7 segment display.
4. If a fault or warning message is displayed, refer to Section 10, Troubleshooting and correct the fault before proceeding.

If the EEPROM contains configuration data, the servo-drive will display the following message:

T200 Monitor:
Starting Drive
EEPROM Start
Wait...
Doing Self
Calibration
Wait...
"Code Version"
EEPROM ID 0
>

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The servo-drive saves data in its Flash EEPROM, which is a non-volatile memory that retains data when power is removed. When power is applied, the servo-drive will attempt to initialize itself using the data in its EEPROM. See Section 6.13 for a description of the operation of the data storage systems of T200.

The servo-drive will be ready to enable once the 7 segment display on the front of the T200 displays either an 'O' character (for T200 is OK) or a 'U'(warning character) followed by a digit.

If the user knows the configuration and parameters are satisfactory the servo-drive may be enabled without any further input from the terminal. This would be the normal procedure after initialization and tuning have been completed.

8.2.1 Motor Configuration

The T200 Servo-drive has motor parameters installed for the G4XX series motors. These are considered "standard motors". Consult the factory for non-standard motor parameters. See Section 4.2 for a description of how to handle non-standard motors. The cross-reference table in Section 4.2 should resolve almost all Moog-non-standard entry issues. This table should help the user to find and enter a standard motor model (which has the same electrical type as the non-standard motor, in most cases), for which the T200's own electrical model database contains all of the required data. The motor's electrical Type, which is printed on the motor nameplate, is used as the table search key to establish the equivalent standard motor model

8.2.2 Standard Motor Configuration

Drive configuration establishes what motor is connected to the T200 Series Servo-drive. The user must perform drive configuration during initial commissioning or replacement of the equipment and any time a different motor is connected to the servo-drive. If the servo-drive does not have valid configuration data in EEPROM, a cold start will occur upon power-up. When a cold start occurs the servo-drive automatically executes a drive configuration command. A 'P' character is displayed on the 7 segment display to indicate that the T200 is in the parameterisation mode. The user will be prompted by the message

SETUP THE MOTOR

(SSM/SNM) >

if a valid motor is not already set-up, in order to configure the drive with the appropriate motor.

The command [SSM] (Set Standard Motor) is used for drive initialization, if the motor is from Moog's standard range of motors. If the motor is a special design, then the command [SNM] (Set Non-Standard Motor) should be used. Example of drive configuration for a Standard Motor:

SETUP THE MOTOR

(SSM/SNM) >SSM<CR>

Enter Drive Configuration Command.

Motor

?

NOTE - The **SSM** command is used to configure the T200 to operate with a STANDARD Moog motor. If the motor is a NON-STANDARD motor, then the **SNM** command should be used. This command prompts the user to enter all appropriate motor parameters. Consult the Moog factory for values of these motor parameters

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After entering the SSM command, the user should then enter a valid motor model number. An example of such a model number is given below.

Drive Disabled

Motor:-

? Enter appropriate motor model number here e.g. G424-400

>

NOTE - It is important that the motor model number is entered correctly as the T200 Series Servo-drive sets many parameters automatically based on this configuration. It is also important to confirm that the proper servo-drive model is connected to the proper motor. The servo-drive type can be checked by using the '**LC**' command. The motor type can be checked by using the '**LM**' command.

The servo-drive is pre-programmed with all motor parameters for standard motor models, (refer to Tables 4-4 and 4-5). For non-standard motor models the user must manually enter the motor parameters (refer to Section Non-Standard Motor Configuration).

Upon entry of the motor model number the T200 will respond as follows:

Wait

Doing Self

Calibration

Wait...

Defaults Set

>

NOTE - Re-configuring the drive by changing the motor type, the compensator etc. will cause all previous tuning information to be lost.

The T200 has now initialised and has set its parameters to the following default values before returning to the input prompt

- Servo-drive in Velocity Mode.
- Limit switches enabled.
- Manual mode enabled.
- Speed scaling set to nominal value of motor speed.
- Low P gain and long I time constant for velocity loop compensator.

This new configuration data will be lost when power is removed unless it is saved to the Flash EEPROM. However, all setup and tuning procedures of Section 6 should be completed before performing this step.

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8.2.3 Non-Standard Motor Configuration

Applications employing non-standard motor models (other than the G4XX series) require the data listed in Table 8.1

PARAMETER	UNITS
Torque Constant (Kt)	Nm/Ar.m.s. or Nm/Aeff
Stator Resistance (Rtt)	Ohms (Ω)
Quadrature Axis Motor Inductance	Millihenries (mH)
Direct Axis Motor Inductance	Millihenries (mH)
Nominal Motor Speed	RPM
Maximum Motor Speed	RPM
Peak Rated Motor Current	Ar.m.s. or Apeak
Current Loop Gain	0 to 15
Number of Motor Poles	Usually 8 or 12 for Moog motors
Rated Continuous Motor Ø Current (Ic)	Ar.m.s. or Apeak
Rated Peak Motor Ø Current (Ip)	Ar.m.s. or Apeak
Motor Nominal Speed	RPM
Current Loop Gain	0 to 15
Motor Observer Inertia (Jm)	$kg\text{-}cm^2$
Resolver Pole Pairs	Usually 2 for Moog motors
Motor Thermistor	True or False

Table 8.1:- Non-Standard Motor Parameter Set

NOTE - The following conversions are useful for motor parameters:
Kt (Nm/ Ar.m.s.) = .113 * Kt (lb-in/Ar.m.s.)
Ic (Ar.m.s.) = Tc (Nm) / Kt (Nm/Ar.m.s.)
Ip (Ar.m.s.) = Tp (Nm) / Kt (Nm/Ar.m.s.)
where:
Ic = Rated Continuous Motor Phase Current
Tc = Rated Continuous Motor Torque
Ip = Rated Peak Motor Phase Current
Tp = Rated Peak Motor Torque

To configure for a non-standard motor, proceed with drive initialization as outlined previously. Use the [SNM] command. Enter the non-standard motor model number when prompted for the motor model number. After confirming the model number entered, the servo-drive will recognize a non-standard motor model number and prompt for entry of the motor parameters listed above.

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8.3 Servo-drive Tuning

Section 6 already contains a comprehensive overview, which is oriented at the Hand-Held terminal interface, on how to tune the T200 control loops. Please refer to this section for a procedure on how to tune the loops.

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8.4 T200 Hand-Held-Terminal Command Set

The following is a list of commands for the hand held pod interface of the T200.

User Information: If the Win-Drive User Interface was previously used with the T200, and the Hand Held Terminal is subsequently used without power cycling of the T200, the user may experience difficulty in establishing communication with the Hand Held Terminal. If this occurs simply type <CR> several times at the Hand Held Terminal and the prompt ‘>’will appear on the display. This prompt indicates that the T200 is now communicating properly with the Hand Held Terminal.

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8.4.1 Drive Set-up Commands

LC **List the Servo-drive Size and Power Configuration**

LV **List the Software Version**

C **Save all parameters** to non-volatile storage

* Enter the Password to **enable privileged mode access**

SUP **Modify the Password** (once in privileged mode)

OR **Set the drive control loop reference source.** Options:

1. **Analogue Input** used as the control loop Reference Source
2. **Internal Function Generator** used as the control loop Reference Source
3. **Point Motion Control Reference Source** used as the control loop Reference Source. Only available when 'Px'software is programmed in the T200.
4. **CAN Profile Mode** Reference Source used as the control loop Reference Source
5. **Digital Inputs Speed Reference**
6. **Excitation Source** (self tuner sets this up automatically). This is used exclusively by WinDrive.
7. **Stepper Motor Interface** (use OSM and OSL to set up the mode and the number of pulses per revolution)

OC **Set the drive control loop operational mode**. Options:

1. Torque Mode only
2. Velocity Mode with 2nd Order torque filter
3. Velocity Mode with 1st Order torque filter
4. Position Loop mode

SD **Sets the axis ID**. If this number is set to a non-zero value, then the hardware HEX Switches are ignored and the value entered here used instead.

LD **List the axis identification number** set by the HEX switches on the front panel of the T200

SU **Set the Parameter Units**
e.g. for torque units, input
[Nm] or [lb-in] in order to setup metric or Imperial units.
For current units, input
[A] or [Arms], in order to enter Apk or Arms.

8.4.2 Motor Set-up Commands

SSM Set **STANDARD** motor parameters. This command is used in the case where the motor is a Moog standard catalogue item.

SNM Set **NON-STANDARD** motor parameters, which prompts the user for the following information, which is available from the motor datasheet:-

- Motor Name e.g. G424-123
- Number of Motor Poles
- Kt (Motor Back-EMF Constant)
- Rtt (Motor phase to phase resistance constant)
- Ltt (Motor phase to phase inductance)
- Ld (Motor direct axis inductance)
- Lq (Motor quadrature axis inductance)
- Nominal Speed (i.e. rated motor speed)
- Maximum Speed (maximum allowed speed for the motor mechanics)
- Peak Current Limit
- Current Loop Gain (I-Gain)
- Number of Resolver Poles
- Continuous Stall Current
- Motor temperature sensing thermistor present or not
- Inertia of motor and load, if available

LM **Lists all motor parameters** with which the drive has been configured.

RO Set the **Resolver Offset Angle**

RP Set the number of **Resolver Poles**

SBV Set the **Bus Voltage**. This is given by (rms phase to phase mains voltage * 1.414)

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8.4.3 Drive Limits Commands

SE Set the **Emergency Deceleration Rate** for Quick-Stops and Limit Switch activation.
SLA **Set the Automatic Mode Velocity Limit**
SLM **Set the Manual Mode Velocity Limit**
STA **Set the Automatic Mode Torque Limit**
STM **Set the Manual Mode Torque Limit**
STT **Set the Torque Rate Time** (i.e. the time over which the torque is allowed to increase to the Torque-Rate-Value)
STV **Set the Torque Rate Value**
SRT Set the **Velocity Rate Time** (i.e. the time over which the velocity is allowed to increase to the Velocity-Rate-Value)
SRV **Set the Velocity Rate Value**

8.4.4 Digital Reference Velocity Commands

SS **Set Digital Reference Velocities** for digital reference mode

8.4.5 Encoder Simulation Commands

OEL **Set the Encoder Simulation Line Count**
OEA **Set the Encoder Simulation Encoder Angle**
OEM **Set the Encoder Simulation Short/Long Marker**
OEO **Enable or disable the Encoder Simulation Filter**, if not in high bandwidth mode.

8.4.6 Incremental Encoder Commands

OIL **Set the number of Incremental Encoder Lines per Revolution**
OILA **Set the number of Incremental Encoder Offset Lines**, from its zero marker

8.4.7 Incremental Encoder Commands

OL **Enable/Disable the Hardware Limit Switches**

8.4.8 Manual Mode Disable Commands

OM **Enable or Disable Manual Mode**

8.4.9 Stepper Motor Interface Commands

OSL Set the **Stepper Motor Number of Pulses per Revolution**
OSM **Set the Stepper Motor Mode:-**
1. Quadrature Mode
2. Step and Direction Mode
3. Up/Down Mode

SFFE **Set Following Error Limit**
LFFE **List Following Error Limit**

8.4.10 Loop Tuning Commands

SN **Set the Velocity Scaling** of the analog input channels, in units of **RPM per 10V**
SR **Set the Position Scaling** of the analog input channels, in units of **Revolutions per 10V**
SI **Set the Integral Time Constant** of the velocity loop compensator
IU **Decrease the Integral Time Constant** of the velocity loop compensator
ID **Increase the Integral Time Constant** of the velocity loop compensator
SP **Set the Velocity Loop Gain P**
PD **Increase the Velocity Loop Gain P**
PU **Decrease the Velocity Loop Gain P**
SW **Set the torque Filter Frequency** (used only when in velocity mode and position mode using 'OC'command)
SZ **Set the torque Filter Damping** (used only when in velocity mode using 'OC' command)
SGI **Set the Position Loop Integral Gain GI**

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SGP	**Set the Position Loop Proportional Gain G**
GD	**Decrease the Position Loop Proportional Gain G**
GU	**Increase the Position Loop Proportional Gain G**
SGT	**Set the Torque Feedforward Gain GT**
SGV	**Set the Velocity Feedforward Gain GV**
SJ	**Set the Observer Inertia J**
JD	**Decrease the Observer Inertia J**
JU	**Increase the Observer Inertia J**
OO	**Enable or disable use of the Observer Velocity Estimate**
SSA VP	**Set Set-Point-Achieved Velocity**
SSA VB	**Set Set-Point-Achieved Velocity Band**
SSAT P	**Set Set-Point-Achieved Torque Percentage** (as a fraction of Peak-Torque of the motor servo-drive combination)
SSAT B	**Set Set-Point-Achieved Torque Band**
OSP	Enable the **Set-Point Achieved fuction**

8.4.11 Diagnostics Commands

OTA	Set the internal process variable which is to be displayed on **analog Test Point A:-** 1. Torque 2. Commanded Velocity 3. Actual Velocity 4. Error Velocity 5. Reference Position 6. Actual Position 7. Error Position 8. Filtered Actual Velocity 9. Observer Estimated Velocity 10. Observer Estimated Error 11. Point Diagnostic Channel 1
OTB	Set the internal process variable which is to be displayed **on analog Test Point B** 1. Torque 2. Commanded Velocity 3. Actual Velocity 4. Error Velocity 5. Reference Position 6. Actual Position 7. Error Position 8. Filtered Actual Velocity 9. Observer Estimated Velocity 10. Observer Estimated Error 11. Point Diagnostic Channel 2
OTP0	Zero **reference the test point output position display variable**
SFI	**Set Mode of Fault Indication**
LFI	**List Mode of Fault Indication**
?B	List the **Power Amplifier heatsink temperature**
?E	List the **Encoder Position**
?F	List the **present fault conditions**
?FL	List the **present latched fault conditions.** NOTE:- the T200 front panel 7-segment display shows all fault conditions, which occurred up until this command, is used. Use of this command then clears the display of such faults, if these faults are no longer present.
?G	Check **Gravity Compensation** Status
?H	List the **Fault History** of the drive.
?L	List the **maximum allowed drive phase** current
?LB	List the **bridge thermal current limit**
?LM	List the **motor thermal current limit**
?LMR	Check the **average motor RMS current** over the last 28s (used for applications sizing)
?LR	List the **RMS thermal current limit**
?LRR	Check the **average regeneration power** expended over the last 28s
?M	List the **motor windings temperature**
?O	Lists **if the Point Extended I/O Card is present** or not.
?P	List the present **Motor Position**
?PF	List Personality **Plug Faults**
?PR	List the present number of **Motor Revolutions** travelled.
?S	List the following **T200 Status** items:- • Programmed Compensator type • Programmed Reference • Torque-Mode • Disabling of Limit Switches • Disabling of Thermal Protect • Disabling of Manual Mode • Indication of Break Released • Enabling of use of the Velocity Observer
?V	List the **present average velocity** of the motor

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8.4.12 Warnings Commands

STD	Set the **position tracking dynamic error** band Δ, in % For a P-position loop: Position-Error = Velocity/Position-G-Gain If Position-Error > Velocity * Δ / G then a CAN warning is issued
STS	Set the **static loop warning position** error, in position increments. If the position error exceeds this, then a CAN warning is issued.
SVL	**Set the warning level** for the Velocity 7-segment warning
SVT	**Set the Warning Time** for the Velocity 7-segment warning
RE	Disable **Regen Exceeded**
ORM	**Set Regen Exceeded Mode**
ORR	**Set Regen Resistor Resistance**

8.4.13 CAN Configuration Commands

SCB	Set the **CAN Baud Rate**
OCS	Set **CAN Position Scaling** for the Interpolation Mode
OGM	Set **gearing M factor**
OGN	Set **gearing N factor**
OHA	Set the **home switch angle** in mechanical degrees
OHP	Set the **home switch polarity**
OHS	Set the **home cycle speed**
OL+	Set the **software position counter clockwise limits**
OL-	Set **the software position clockwise limits**
OLS	**Enable/Disable the software limit switches**
OMR	Select the **reference or actual** as the source of the Master Angle
?C	Check **CAN Status**
SCB	Set the **CAN Baud Rate in kBaud**
SCR	Set the **CAN-Communication Cycle Period**
OCM	Choose the **CAN Mode** 1. Profile Mode 2. Interpolation Mode
T	Invoke the **Motion Control Menu**

8.4.14 Local Mode Control Commands

OFA	Set the **Function Generator Acceleration**
OFD	Set the **Function Generator Duty Cycle**
OFI	**Start the Function Generator** (used in position mode only, as set using the 'OC' command)
OFN	Set the **Function Generator Speed** Amplitude
OFNO	Set the **Function Generator Speed Offset**
OFO	**Stop the Function Generator** (used in position mode only, as set using the 'OC' command)
OFP	Set the **Function Generator Period**
OFS	Set the **Function Generator Position Traverse**
OFT	Set the **Function Generator Torque Amplitude**
OFTO	Set the **Function Generator Torque Offset**
MB	**Apply / Release the motor braka**
MI	**Enable the T200** (the hardware enable must already be conducting current)
MO	**Disable the drive**
MQ	**Quick Stop the drive**
MT	**Set the drive into Torque Mode** (ONLY functions if the drive is already in velocity mode).
MV	**Set the drive into Velocity Mode** (ONLY functions if the drive is now programmed to velocity mode, but has been switched to torque mode using the 'MT' command)

8.4.15 Invert Output Polarity Commands

OIS	**Invert System Ready Relay** polarity
OIT	**Invert Thermal Limit Active Output** polarity

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8.4.16 Thermal Protection Commands

IT Set the **IT Protection parameters**:
- Ipeak
- Icont
- Max Time at Ipeak

OD **Disable the Thermal Protection**

8.4.17 User-Calibration Commands

OI	**Set the Analog Input Offset** on the analog reference input
OZ	**Zero the Analog Input Offset** on the analog reference input
RDCO	Set the **resolver interface Cosine channel offset**
RDSO	Set the **resolver interface Sine channel offset**
RDGF	Set the **gain matching coefficient between the Sine and Cosine** channels of the resolver interface

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SECTION 9: CAN INSTALLATION

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9.1 Introduction

CAN is an abbreviation for the Controller Area Network. This is a high speed serial interface which was designed for use in Automotive and Industrial applications.

The T200 provides two CAN Modes of operation:-

1. CAN Interpolation Mode:- The System Motion Controller transmits target positions at high data rates, and the T200 finely interpolates these positions to follow the target trajectory.
2. CAN Profile Mode. The System Motion Controller offloads complex motion calculations to the T200, which provides the following functions:-
   - *Point to Point Mode*. The Control Computer transmits a target position, velocity and acceleration via the CAN interface. The T200 generates a smooth trajectory to the target position using this data.
   - *Gearing Mode*. A 'master' T200 generates a 'Master-Angle' position reference at a high rate. One or many T200 'slaves' receive this reference. These slaves multiple the 'Master-Angle' by a user programmed factor, and use the result as their command position.
   - *Camming Mode*. Slave T200's simulate a mechanical cam with high precision. Slave T200's transform the 'Master-Angle' through a user defined cam shape, and use the result as their command position.
   - *Velocity Mode*. The T200 operates in velocity mode, with the command velocity and torque limit transmitted at high speed via the CAN interface.

CAN Profile and Interpolation modes are described in detail in additional documents:-

1. CAN Protocol for Interpolation Mode and
2. CAN Protocol for Profile Mode

These documents are available on request from Moog Sales Outlets (See Section 11 for addresses and phone numbers).

Users are directed to read Section 2, Safety Instructions, before proceeding with installation.

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9.2 CAN Cable Wiring

The CAN-In and CAN-Out ports at J2 and J3 of the T200 provide the means to daisy-chain the CAN cabling between T200 units. Note:-

1. CAN lines must be terminated in a 120Ohm resistance, between the positive and negative terminals (CAN-High and CAN-Low).
2. The CAN circuitry is isolated from the T200 logic power. An internal DC/DC – converter generates the supply voltage for the isolated CAN interface.

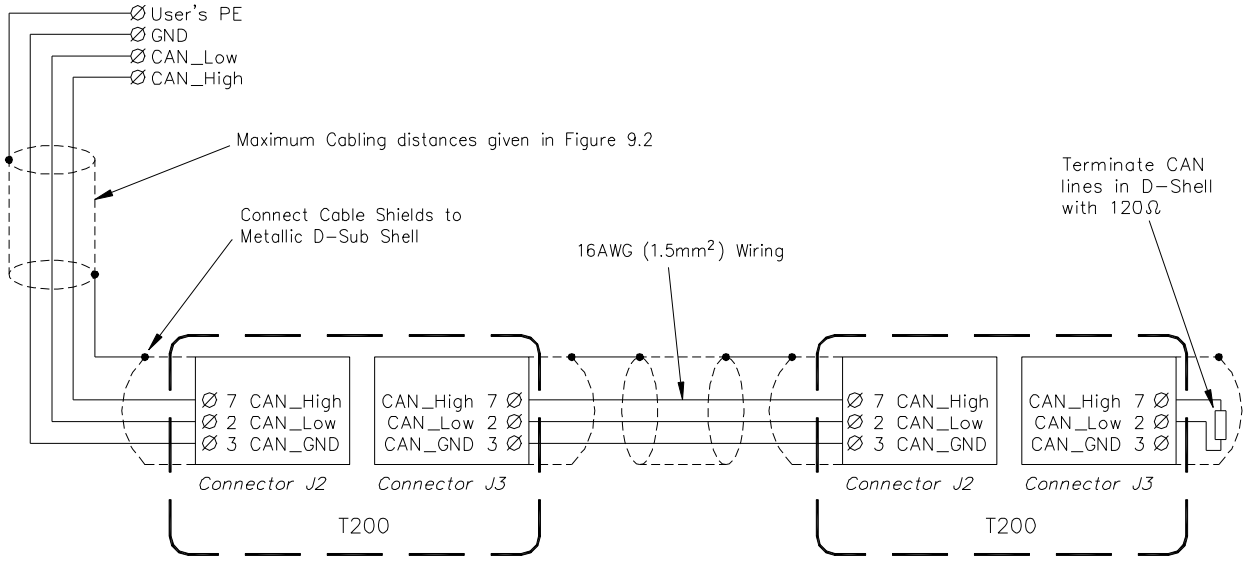

Figure 9.1:- CAN Wiring and Termination

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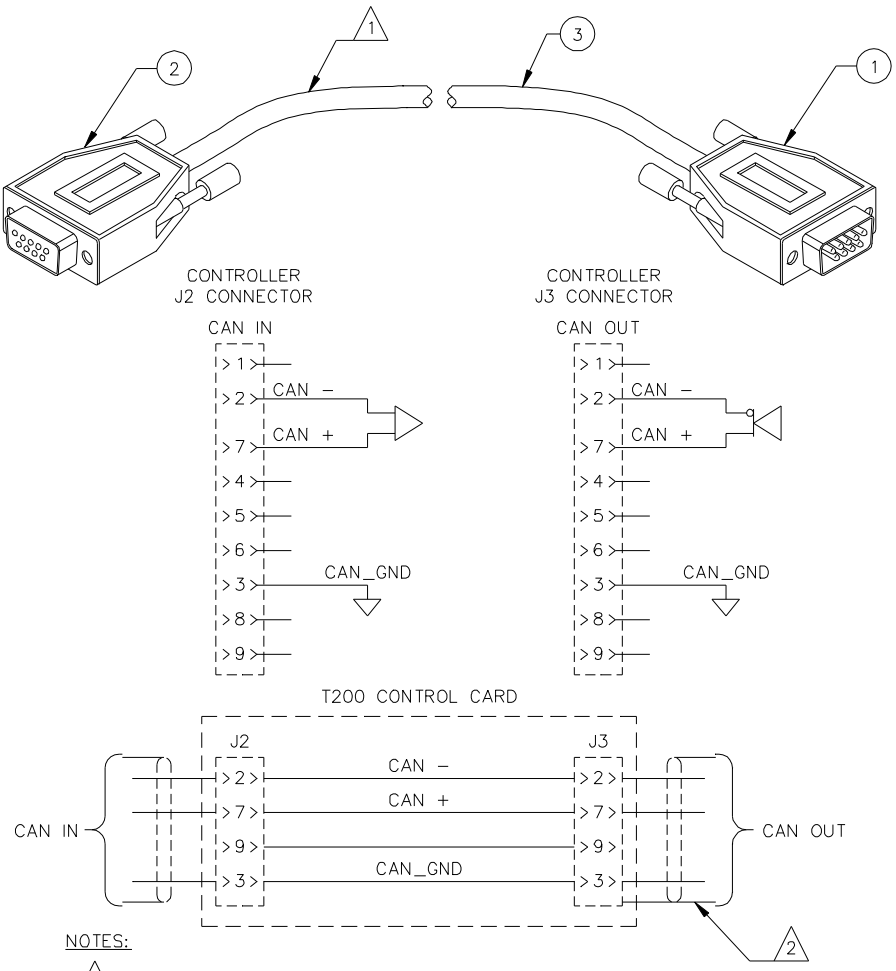

FIND NO.	MOOG PART NO.	DESCRIPTION	QUANTITY
1	MAKE ITEM	CONNECTOR 9 WAY D TYPE MALE	USER SUPPLIED
2	MAKE ITEM	CONNECTOR 9 WAY D TYPE FEMALE	USER SUPPLIED
3	MAKE ITEM	CABLE BELDEN 9842	USER SUPPLIED

Figure 9.2:- CAN-In/CAN-Out Connector (J2 and J3) Wiring

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SECTION 10: TROUBLE-SHOOTING GUIDE

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How to use this Section

The table of contents below should help the user to understand problems and find solutions. The status of the T200 power status LED's and 7-segment display is used as the starting point.

- The user should check if a fault or warning code is displayed on the 7-segment display. If so the user can use the table of contents below as a cross-reference to the appropriate troubleshooting section.
- If no useful status, warning or fault code is present on the 7-segment display, then the user can check the 'Other Problem Sources' section to find help on troubleshooting.

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10.1 Introduction

The following tables list typical system, controller, and motor troubleshooting conditions. A list of possible cause(s) is given for each condition. For some conditions, there are multiple possible causes which are generally listed in order of increasing complexity or decreasing likelihood for the stated conditions. A list of check/correct action recommendations are listed below each possible cause(s).

The T200 provides extensive diagnosis of fault conditions and warnings, as well as high power status information. This diagnostic information is intended to aid in the troubleshooting of applications and controller problems. The following sections explain why high power status LED are illuminated, and what problem sources can cause faults and warnings to be displayed on the 7-segment display. Additional diagnosis information is provided for other sources of faults.

WARNING: Do not attempt to repair or make internal adjustments to the controller or power supply. Lethal voltages are present and changes to factory calibration can result in serious equipment and/or personnel risk and void the equipment warranty. All faulty items of this equipment must be returned to Moog Service Centres for maintenance and repair.

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10.2 Power Status LED's not Illuminated

Section 3.19 T200 User Visual Indications outlines the functionality of the power status LED's on the T200. The following is list of problem sources and corrective actions when these LED's fail to illuminate, or in the case of the REGEN-ACTIVE LED, is constantly illuminated.

10.2.1 Fault Type: Mains-Applied LED is not lighting (T200-X10 ONLY)

Table 1: Causes of Mains Applied LED not illuminated

Cause	Check/[Correction]
a.c. Mains Power disconnected from T200 TB2 Connector	▪ Single phase or three phase a.c. mains plant supply is available [Switch-on plant a.c. mains power if safe to do so] ▪ a.c. Mains Input Circuit Breaker conduction status. [Switch circuit breaker to conduction if safe to do so] ▪ Repeated Earth Leakage Circuit Breaker trips. The T200 can have earth leakage currents up to 10mA per phase, if no isolation transformer is used. [Use an Earth Leakage Circuit Breaker with a trip level of higher than 30mA. Alternatively install an isolation transformer to remove nuisance earth leakage currents.] ▪ IF PRESENT, check a.c. Mains Conducted Emissions Filter wiring and mis-connections [Check single phase filter wiring against recommended wiring practise] ▪ Optional a.c. mains contactor is closed (user option to supply this) [Check user control circuits and interlocks which may prevent the mains contactor from closing. Check interlock systems which use the T200s' System Ready Relay fault status indication output] ▪ Transformer termination mis-wired or not connected [Check the wiring of the user-supplied transformer]
a.c. Mains Voltage too Low	Magnitude of a.c. Mains voltage Line to Line at TB2. a.c. voltage should be in range 100V r.m.s. to 255Vr.m.s. [a.c. Voltage may be too small to drive the T200 internal power electronics circuitry, without tripping fast bus discharge circuitry. Ensure that the a.c. mains voltage magnitude is within the range listed above].

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10.2.2 Fault Type: DC-Bus-Active LED is not Lighting

Table 2: Causes of DC-Bus-Active LED not lighting

Cause	Check/[Correction]
a.c. Mains not Applied (T200-X10 Units ONLY)	Check Mains Applied LED status. If this is not lit then the DC-Bus-Active LED cannot be illuminated. [Corrections as per Fault Type: Mains-Applied LED is not lighting (T200-X10 ONLY)]
Regeneration Fuse Blown (T200-X10 Units ONLY)	Check for F3 Fault on the 7-segment display that indicates that the internal regeneration resistor fuse is blown. Repeated a.c. mains power-on cycles within a short period will cause repeated softstart cycles. These will eventually cause the fuse to be blown. WARNING: The T200 should never be opened. Consult Moog Applications Engineering for help on replacement of the fuse. [Reduce the frequency of power-on/off cycles to be less than one cycle every 4.5 seconds. Alternatively reduce the number of T200-X00's (units without integral High-Power PSU)] which are connected to the T200-X10 (unit with integral High-Power PSU).]
Too Many T200-X00 Units Connected to DC-Bus	Too many T200-X00 Units connected to the T200-X10 unit will cause the softstart mechanism to malfunction. Note that a maximum of 4 T200-X00 units can be connected to a T200-X10 unit [Reduce the number of T200-X00's (units without integral High-Power PSU) which are connected to the T200-X10 (unit with integral High-Power PSU)].
DC-Bus Fuse Blown in T200-X10	The DC-Bus Active LED does not light in T200-X00's, but does light in T200-X10's. [Check the DC-Bus wiring interconnect to all connected T200-X00 units, as outlined in Section 3. In particular check that the DC-Bus wiring from the T200-X10's TB3 connector has not been reversed in polarity when connected to the T200-X00's TB2 connector, or that DC+ and DC- terminals have not been connected to PE (protective earth).] **WARNING**: The T200 should never be opened. Consult Moog Applications Engineering for help on replacement of the DC-Bus output fuse.

10.2.3 Fault Type: Regen-Active LED always lighting (T200-X10 ONLY)

Table 3: Causes of Regen-Active LED constantly illuminated

Cause	Check/[Correction]
Logic Backup Power is Applied, a.c. Mains Voltage is NOT Applied	Same checks and corrections as Fault Type: Mains-Applied LED is not lighting (T200-X10 ONLY)

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10.3 Seven-Segment Display Status

The following section deals with T200 7-segment display status conditions. These are conditions that indicate to the user a particular T200 state. They may or may not indicate real problems with the unit. For example, if the 7-segment display is not illuminated, then there is no high voltage or logic backup power applied to the T200.

10.3.1 Fault Type: 7-Segment Display does not Illuminate

The 7-segment display will always illuminate when sufficient logic power is available in the T200. Logic power is derived from the high voltage DC-Bus, or the 24V d.c. or 120V a.c. mains input.

Table 4: Causes of 7-Segment Display not illuminated

Cause	Check/[Correction]
High Power source has not been applied	The high voltage a.c. mains or the high voltage d.c. bus power is not available at TB2. [Check the availability of high power by checking the status of the Mains-Applied and the Bus-Active LED's]
24Vd.c. or 120Va.c. Backup Power not Applied	24V d.c. or 120Va.c. Logic backup power availability. [Check the presence of the user supplied backup power source]
24V Backup Power Reversed	The 24V d.c. power source pins have been reversed. [Check the polarity of the connection of the 24Vd.c. inputs power connection on TB5. Note that the input has a resetable fuse. When the polarity is corrected, the fuse will return to the conduction mode.]

10.3.2 Status Type: 'P' constantly on 7-segment Display

The 7-segment display will always illuminate when sufficient logic power is available in the T200. Logic power is derived from the high voltage DC-Bus, or the 24V d.c. or 120V a.c. mains input.

Table 5: Causes of Constant 'P' on 7-segment Display

Cause	Check/[Correction]
Motor has not been Configured	The motor has not been correctly configured. [Check Section 4.2 on how to configure a standard or non-standard motor in the T200. Configure the motor, set-up the appropriate control configuration in the T200 and save the configuration to the non-volatile storage.]
Incorrect Software Configuration	The T200 software has been configured in a mode which does not allow it to continue without risk of damage to the T200, the motor or the load. [Upload the motor configuration using the WinDrive File-Configuration Upload command. Fax or email the uploaded .log configuration file to the Moog Application Engineers.]

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10.4 'F' Symbol Followed by Number on Seven-Segment Display (Faults)

The following section deals with fatal T200 faults. These are fault conditions, which cause the T200 to immediately remove high power from its power amplifier. If the fault condition has not been removed, then the T200 cannot generate torque in the motor.

10.4.1 Fault Type: F1 (Phase Overcurrent) on 7-segment Display

The F1 fault is displayed when a motor phase over-current has occurred. The T200 disabled itself immediately when the fault occurred.

Table 6: Causes of F1 on 7-segment Display

Cause	Check/[Correction]
Short Circuit on Motor Phase	There is a short circuit from one of the motor phases (U, V, W on TB8) to one of the other phases, to the DC-Bus terminals (DC+ and DC- on TB3) or to Protective Earth. [Check the wiring and remove the short circuit]
Incorrect Motor Configured in Software	An incorrect motor has been configured, and motor over-current occurs, especially during a high deceleration movement of the motor. [Check the motor nameplate and configure the correct motor in the T200 per Section 4.2 of this manual. If the motor is a non-Moog motor then check that all of the motor parameters have been entered in the WinDrive dialog box (see Section 7.10.1.2 or Section 8.2.3)]
Incorrect Current Loop Gain	The current loop gain is not sufficient for adequate control of phase currents, if the motor is a non-Moog motor. [Check the motor parameters (Section 7.10.1.2), and fax or email these to Moog Applications Engineering for calculation of current loop gain for the non-Moog motor.]

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10.4.2 Fault Type: F2 (DC-Bus Overvoltage) on 7-segment Display

The F2 fault is displayed when the DC-Bus voltage exceeds 400V d.c. The T200 disabled itself immediately when the fault occurred.

Table 7: Causes of F2 on 7-segment Display

Cause	Check/[Correction]
Internal Regeneration Resistor not adequate	The internal regeneration resistor is not adequate to dissipate the kinetic energy returned from the load, when the motor decelerates, or has to hold an overrunning or vertical axis with a heavy load. [Install an external regeneration resistor as detailed in Section 3.13.]
Load Deceleration is Excessive	The deceleration of the load is excessive, and regenerative energy is returned too fast for the regeneration resistor to dissipate. [Decrease the deceleration rate programmed in the motion control system. Alternatively use an external regeneration resistor.]
Load Returning too much Power	As above the load returns too much power. Check the continuous regeneration energy return, using the Hand-Held Terminal '?LRR' command. [If a vertical load is carried, a counterbalance may be needed. Alternatively a larger sized T200, with extra regenerative power capability may be required. See Section 3.13 for ratings.]
High Line Voltage/ Incorrect Transformer Tap	The line voltage at TB2 is too high. Measure the a.c. mains voltage at TB2 of the T200-X10 (unit with integral PSU). Check the step down transformer, to see if the tap off the secondary side of the transformer is at the correct position. [Install a step down transformer. OR Correct the transformer wiring.]

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10.4.3 Fault Type: F3 (Fuse Fault) on 7-Segment Display

The F3 fault is displayed when either the internal regeneration resistor fuse (ONLY on T200-X10 units) or the DC bus fuse or both fuses have blown. If the drive is enabled the T200 decelerates and disables itself immediately when the fault occurs. The controller cannot be enabled if it is disabled when the fault occurs.

Table 8: Causes of F3 on 7-segment Display

Cause	Check/[Correction]
Excessive Rate of Power Cycling	Repeated a.c. mains power-on cycles within a short period will cause repeated softstart cycles. These will eventually cause the fuse to be blown. WARNING: The T200 should never be opened. Consult Moog Applications Engineering for help on replacement of the fuse. [Reduce the frequency of power-on/off cycles to be less than one cycle every 4.5 seconds.]
Too Many T200-X00 Units Connected	• Too many T200-X00 units connected to the T200-X10 unit will cause the softstart mechanism to malfunction. Note that a maximum of 4 T200-X00 units can be connected to a T200-X10 unit. This will cause the Internal Regeneration Resistor fuse to blow. • The T200-X00 connected to the T200-X10 draw too much current from the DC bus during normal operation. This will cause the DC bus fuse to blow. [Reduce the number of T200-X00's (units without integral High-Power PSU) which are connected to the T200-X10 (unit with integral High-Power PSU).]
Load Returning too much Power	As above the load returns too much power. [If a vertical load is carried, a counterbalance may be needed. Alternatively a larger sized T200, with extra regenerative power capability may be required. See Section 3.13 for ratings.]
DC Bus Daisy Chain connection mis-wired	If the DC Bus Daisy Chain connection is mis-wired (i.e. the two wires have been swapped), excessive current will be drawn from the DC bus output prior to where the mis-wiring occurred. This will cause the DC bus fuse to blow. [Correct the wiring of the DC bus daisy chain.]

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10.4.4 Fault Type: F4 (PSU Heatsink Overtemperature) on 7-Segment Display

The F4 fault is displayed when the High Power PSU Heatsink Temperature is excessive. The T200 decelerates and disables itself immediately when the fault occurs.

Table 9: Causes of F4 on 7-segment Display

Cause	Check/[Correction]
Too Many T200-X00's Connected	Too many T200-X00 (units without integral PSU) have been connected to the T200-X10 (unit with integral high power PSU). [Install another T200-X10 to share the DC-Bus power generation load.]
Heatsink Fan Failure	One or more of the integral fans has failed. If possible to do safely, check that these fans are circulating air. [If internal cooling fans have failed, return the unit to Moog]. The ambient temperature may be too high in the cabinet. [Check that the ambient temperature does not exceed 55°C.]

10.4.5 Fault Type: F5 (Power Amplifier Over-temperature) on 7-segment Display

The F5 fault is displayed when the power amplifier heat-sink temperature is excessive. The T200 decelerates and disables itself immediately when the fault occurs.

Table 10: Causes of F5 on 7-segment Display

Cause	Check/[Correction]
Ambient Temperature Too High	The T200 is rated for a maximum ambient temperature of 55°C. The ambient temperature may exceed that in certain cases. Measure the ambient temperature in the T200 cabinet [Provide improved outside air circulation in the cabinet.]
Heatsink Fan Failure	One or more of the integral fans has failed. If possible to do safely, check that these fans are circulating air. [If internal cooling fans have failed, return the unit to Moog.]
Excessive Static Load	The machine bearings or other parts may have become seized or severely worn. This can cause extra friction or load torques. [Check the freedom of rotation of the load, including bearing wearing and load alignment.]
Movement Duty Cycle Excessive	The acceleration and deceleration of the movement, as well as the frequency of movement may be excessive for the T200. [Decrease the duty cycle, by reduction of the acceleration and deceleration, and/or the frequency of the movement]
T200 Undersized	The T200 is not rated to handle the current duty cycle required by the application. Use the ?LMR Hand Held terminal command to measure the motor phase r.m.s. current. Check is this very near the rating of the T200. [Install a T200 with the correct current rating if this is available.]

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10.4.6 Fault Type: F6 (Motor Over-Temperature) on 7-Segment Display

The F6 fault is displayed when the motor temperature is too high (at or greater than 155°C). The T200 decelerates and disabled itself immediately when the fault occurs.

Table 11: Causes of F6 on 7-segment Display

Cause	Check/[Correction]
Inadequate Thermal Contact between Motor and Mounting	The motor is rated to operate with a maximum temperature rise of 100°C above ambient, when operated at its rated continuous power level. This depends upon suitable thermal contact between the motor and its mounting. Check the amount of physical contact between the motor and the surrounding mounting metalwork. [Provide improved thermal conduction between the motor and its mounting if possible.]
Inadequate cooling airflow over the motor.	There is inadequate cooling airflow over the motor. [If possible, duct extra airflow from a cool ambient area over and around the motor.]
Excessive Static Load	The machine bearings or other parts may have become seized or severely worn. This can cause extra friction or load torques. [Check the freedom of rotation of the load, including bearing wearing and load alignment.]
Movement Duty Cycle Excessive	The acceleration and deceleration of the movement, as well as the frequency of movement may be excessive for the motor. [Decrease the duty cycle, by reduction of the acceleration and deceleration, and/or the frequency of the movement]
Motor Undersized	The motor is not rated to handle the current duty cycle required by the application. Use the ?LMR Hand Held terminal command to measure the motor phase r.m.s. current. Check if this very near the rating of the motor. [Install a motor with a high current rating if this is suitable for the application]
Ambient Temperature too High	The ambient air temperature is too high around the motor. Check the ambient air temperature. [Extra airflow around the motor using fans or air-conditioning, if possible.]

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10.4.7 Fault Type: F7 (Internal Software Fault) on 7-Segment Display

The F7 fault is displayed when an internal software error has occurred. The T200 disabled itself immediately when the fault occurred.

Table 12: Causes of F7 on 7-segment Display

Cause	Check/[Correction]
Software Mis-Configuration	The software error should rarely if ever occur. It is due to a critical mis-configuration of the software which causes improper operation of the software (e.g. divide by zero exception to occur) [Upload the software configuration using the WinDrive File, Configuration-Upload command, to a .log file. Email or fax a copy of this .log file to Moog Applications Engineering. Completely reconfigure the T200 from motor configuration onwards in order to bring the T200 back into operation.]

10.4.8 Fault Type: F8 (Resolver Fault) on 7-segment Display

The F8 fault is displayed when a resolver position transducer error has occurred. The T200 disabled itself immediately when the fault occurred.

Table 13: Causes of F8 on 7-segment Display

Cause	Check/[Correction]
Resolver Cable Disconnected, or Mis-Wired	The resolver cable is either not connected, has been wired incorrectly, or has become disconnected or broken. [Check the wiring of the resolver cable. Ensure that it is wired as per Figure 3.33, Table 3.8.]
Non-Moog Resolver Type Used	The user has connected the T200 to a non-Moog motor, whose resolver electrical characteristics do not match those expected by the T200. [Contact Moog Applications Engineering with a description of the resolver parameters.]
Resolver Bad	Faulty resolver in the motor. Remove all power from the T200. Swap the motor if possible with another known good motor and check is a resolver fault present with the known motor. [Return motor to Moog.]

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10.4.9 Fault Type: F9 (Internal DC/DC Fault) on 7-segment Display

The F9 fault is displayed when a internal analogue power supplies are below acceptable voltage levels. The T200 disabled itself immediately when the fault occurred.

Table 10: Causes of F9 on 7-segment Display

Cause	Check/[Correction]
Internal DC/DC Error	The internal DC/DC which generates ±15V supplies has malfunctioned. [This error should never occur. Return the T200 unit to the factory or sales outlet immediately for analysis, and a report on the cause of the problem.]

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10.5 'U' Symbol Followed by Number on Seven-Segment Display (Warnings)

The following section deals with T200 warnings. These are usually fault conditions which do not require that the T200 immediately remove high power from its power amplifier. However some of these warning conditions will cause the T200 to servo-stop and disable.

10.5.1 Warning Type: U1 (a.c. Mains has not been applied) on 7-Segment Display

The U1 Warning is displayed when a.c. Mains power has not been applied on T200-X10 units, OR the Power-RDY digital input has not been activated on T200-X00 units. The T200 cannot generate torque in the motor when U1 is present.

Table 14: Causes of U1 on 7-Segment Display

Cause	Check/[Correction]
A.C. Mains Power has not been applied (T200-X10 units ONLY)	The high voltage a.c. mains is not available at TB2. Check the availability of high power by checking the status of the Mains-Applied and the Bus-Active LED's. [Check using Section a.c. Mains Power disconnected from T200 TB2 Connector, that the mains can be safely reconnected to TB2.]
Power Ready digital input has not been activated (T200-X00 units ONLY)	Check the status of the Power Ready digital input. This can be done by using the WinDrive, Drive, Drive-Status menu item. [Check that the PWR-RDY digital input on J1 of this T200-X00, has been driven by the PWR_RDY± relay output on TB4 of a T200-X10 which supplies DC-Bus high voltage to this T200-X00.]

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10.5.2 Warning Type: U2 (Motor Temperature Warning) on 7-Segment Display

The U2 warning is displayed when the motor temperature exceeds 130°C. The T200 can generate reduced torque in the motor when U2 is present.

Table 15: Causes of U2 on 7-Segment Display

Cause	Check/[Correction]
Inadequate Thermal Contact between Motor and Mounting	The motor is rated to operate with a maximum temperature rise of 100°C above ambient, when operated at its rated continuous power level. This depends upon suitable thermal contact between the motor and its mounting. Check the amount of physical contact between the motor and the surrounding mounting metalwork. [Provide improved thermal conduction between the motor and its mounting if possible.]
Inadequate cooling airflow over the motor.	There is inadequate cooling airflow over the motor. [If possible, duct extra airflow from a cool ambient area over and around the motor.]
Excessive Static Load	The machine bearings or other parts may have become seized or severely worn. This can cause extra friction or load torques. [Check the freedom of rotation of the load, including bearing wearing and load alignment.]
Movement Duty Cycle Excessive	The acceleration and deceleration of the movement, as well as the frequency of movement may be excessive for the motor. [Decrease the duty cycle, by reduction of the acceleration and deceleration, and/or the frequency of the movement]
Motor Undersized	The motor is not rated to handle the current duty cycle required by the application. Use the ?LMR Hand Held terminal command to measure the motor phase r.m.s. current. Check if this very near the rating of the motor. [Install a motor with a high current rating if this is suitable for the application]

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10.5.3 Warning Type: U3 (Power Amplifier Warning) on 7-Segment Display

The U3 warning is displayed when the power amplifier internal heatsink temperature comes within about 10°C of its fault temperature. The warning may only signify that the T200 is being used close to its thermal limits. The T200 can generate torque in the motor when U3 is present.

Table 16: Causes of U3 on 7-Segment Display

Cause	Check/[Correction]
Ambient Temperature Too High	The T200 is rated for a maximum ambient temperature of 55°C. The ambient temperature may exceed that in certain cases. Measure the ambient temperature in the T200 cabinet. [Provide improved outside air circulation in the cabinet.]
Heatsink Fan Failure	One or more of the integral fans has failed. If possible to do safely, check that these fans are circulating air. [If internal cooling fans have failed, return the unit to Moog.]
Excessive Static Load	The machine bearings or other parts may have become seized or severely worn. This can cause extra friction or load torques. [Check the freedom of rotation of the load, including bearing wearing and load alignment.]
Movement Duty Cycle Excessive	The acceleration and deceleration of the movement, as well as the frequency of movement may be excessive for the T200. [Decrease the duty cycle, by reduction of the acceleration and deceleration, and/or the frequency of the movement.]
T200 Undersized	The T200 is not rated to handle the current duty cycle required by the application. Use the "?LMR" Hand Held terminal command to measure the motor phase r.m.s. current. Check if this value is greater than or above the rating of the T200. [Install a T200 with a high current rating if this is available.]

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10.5.4 Warning Type: U4 (Position Error Warning) on 7-Segment Display

The U4 Warning is displayed when the T200 position error exceeds the user-programmed range (see Section 6.6.3 for an overview of position error monitoring). The T200 can generate torque in the motor when U4 is present.

Table 17: Causes of U4 on 7-Segment Display

Cause	Check/[Correction]
Loop Tuning not Adequate	The loop tuning will determine the amount of position error which occur during a specific movement. Increase the gains in the loop if possible. [The P and I gains need to be set appropriately for the load (see Section 6.6.3, Velocity Loop Tuning). In certain cases the velocity observer can be used to significantly increase the value of these gains (see Section 6, Velocity Observer Tuning and Usage). The G gain needs to be set (see Section 6.6.3, Position Loop Tuning). Advanced Tuning for T200 Applications which use the CAN interface - In CAN systems the velocity feedforward term GV should be set to 1 to decrease the position loop error. In certain systems the torque feedforward term GT should be set equal to the combined motor + load inertia, to decrease position error during the acceleration and deceleration phases.]
Programmable Torque and Velocity Limits too Low	The user configures the manual and automatic velocity limits, for the application at hand. These limits may be set too low. [Increase the velocity and torque limits, when ensuring the safe operation of the machine.]
Drive has been placed in Manual Mode	The drive has been commanded into manual mode, either through the AUTO-MAN digital input on J1, or through the CAN interface. [Check why the T200 has been forced into manual mode: Check the wiring of the AUTO_MAN input. Check the safety status of the machine control system.]
Analog Torque Limit is Active	The analog torque limit is an analog interface which allows dynamic limiting of torque. [If the input is not used, then short the SAIN+ and SAIN- pins at the J1 connector.]
Excessive Static or Dynamic Load	The machine bearings or other parts may have become seized or severely worn. This can cause extra friction or load torques. [Check the freedom of rotation of the load, including bearing wearing and load alignment.]
Movement's Duty-Cycle is Excessive	The acceleration and deceleration of the movement, as well as the frequency of movement may be excessive for the T200. [Decrease the torque necessary during the movement, by reduction of the acceleration and deceleration, and/or the frequency of the movement.]

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10.5.5 Warning Type: U5 (Velocity Error Warning) on 7-Segment Display

The U5 Warning is displayed when the T200 velocity error exceeds the user-programmed range (see Section 6.6.2 for an overview of velocity error monitoring). The T200 can generate torque in the motor when U5 is present.

Table 18: Causes of U5 on 7-Segment Display

Cause	Check/[Correction]
Loop Tuning not Adequate	The velocity loop tuning will determine the amount of velocity error, which occurs during a specific movement. Increase the gains in the loop if possible. [The P and I gains need to be set appropriately for the load (see Section 6.6.2, Velocity Loop Tuning). In certain cases the velocity observer can be used to significantly increase the value of these gains (see Section 6.6.2, Velocity Observer Tuning and Usage).]
Programmable Torque and Velocity Limits too Low	The user configures the manual and automatic velocity limits, for the application at hand. These limits may be set too low. [Increase the velocity and torque limits, when ensuring the safe operation of the machine.]
Drive has been placed in Manual Mode	The drive has been commanded into manual mode, either through the AUTO-MAN digital input on J1 or through the CAN interface. [Check why the T200 has been forced into manual mode: Check the wiring of the AUTO_MAN input Check the safety status of the machine control system.]
Analog Torque Limit is Active	The analog torque limit is an analog interface, which allows dynamic limiting of torque. [If the input is not used, then short the SAIN+ and SAIN- pins at the J1 connector.]
Excessive Static or Dynamic Load	The machine bearings or other parts may have become seized or severely worn. This can cause extra friction or load torques. [Check the freedom of rotation of the load, including bearing wearing and load alignment.]
Movement's Duty-Cycle is Excessive	The acceleration and deceleration of the movement, as well as the frequency of movement may be excessive for the T200. [Decrease the duty cycle, by reduction of the acceleration and deceleration, and/or the frequency of the movement.]

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10.5.6 Warning Type: U6 (External Regen Resistor Warning) on 7-segment Display

The U6 warning is displayed when the thermal rating of the external regeneration resistor has been exceeded. The T200 can generate torque in the motor when U6 is present.

Table 19: Causes of U6 on 7-segment Display

Cause	Check/[Correction]
External Regeneration Resistor Continuous Rating Exceeded	The T200 monitors the external regeneration resistor load cycle to check if its continuous rating is exceeded. Check using the Hand Held Terminal's ?LRR command what is the average power dissipation in the external resistor. Compare this number against the ratings provided in Section 3.13. [Decrease the duty cycle, by reduction of the acceleration and deceleration, and/or the frequency of the movement.]

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10.5.7 Warning Type: U7 (CAN Communications Warning) on 7-segment Display

The U7 warning is displayed when the CAN interface has malfunctioned. The T200 will servo-stop, apply the brake if present, and then disable when U7 occurs.

Table 20: Causes of U7 on 7-segment Display

Cause	Check/[Correction]
CAN Cable Disconnected	CAN cable pin(s) have become disconnected, resulting in a break in CAN communications. [Check the CAN cable wiring, as per Section 9.]
Master Control System Malfunction	Check that the master control computer has power-up correctly, and that it has started its CAN communications process. [Start the System Motion Controller, as required.]
CAN Parameters Incorrect	The CAN Parameters Baud-Rate, Communication-Cycle-Period, Actual Window Time and Command Window Time have to be set appropriately, and at the same values in all T200's which communicate on the same CAN cable. The Node-ID's also have to be set correctly to a unique number for each node. [See Section 9 for an overview of suitable values for these parameters.]
Excessive Noise on CAN Cable	There is excessive noise interference on the CAN Cabling. Check: ▪ Recommended cable type or equivalent type is used. Cable with characteristic impedance of 120Ohms is recommended. ▪ CAN Cable Termination with 120Ohms, at the physical extremities of the cabling ONLY. ▪ Connection of all pins, especially the GND and Cable-Shield connections, at all connected end of the cabling. ▪ CAN Cabling Routing, if alongside high current cabling [Ensure there is only two termination resistors, at the physical end of the cabling Correct mis-wiring. Route cables away from motor power or other cables, which carry high currents if possible.]
Software Configuration Error	The Software has been mis-configured, with parameters, which are unachievable. [Review Section 9, and re-configure the T200 correctly.]

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10.5.8 Warning Type: U8 (Limit Switches Warning) on 7-segment Display

The U8 warning is displayed when the Limit Switches (digital inputs on J1) have been activated, and they have not been disabled through software control. The T200 can still generate torque when the limit switches have been activated.

Table 21: Causes of U8 on 7-segment Display

Cause	Check/[Correction]
Limit Switches not Disabled	The application does not require that the limit switches are used. [Disable the Limit Switches using the WinDrive or Hand Held Terminal interface ('OL' command.) OR Hardwire the digital inputs, to always conduct current, such that they are never activated.]
Axis has run into Forbidden Area	The application requires that the limit switches are used. The axis has activated the limit switches because its has exceeded its allowed work zone. [Reposition the axis using a homing or other absolute position referencing scheme. Restart the work cycle. OR Change the position of the limit switches if these are incorrectly positioned.]
Limit Switches broken or disconnected	The Limit Switch may be broken. Move the axis in a working zone and verify that the switch deactivates. [Replace the switch or the wiring.]

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10.5.9 Warning Type: UA (Quick-Stop Warning) on 7-segment Display

The UA warning is displayed when the servo-stop function is active, ONLY IF the Reference Source is the CAN interface, in Interpolation Mode.

Table 22: Causes of UA on 7-segment Display

Cause	Check/[Correction]
Quick-Stop digital input has been activated	Check the activity state of the Quick-Stop Digital input. This input is otherwise known as PROG_SPD_0 of J1, which has the alternative use of Quick-stop when the Reference Source is CAN.) [To check for a problem: ▪ Correct the Quick-Stop digital input wiring ▪ Correct the event which caused the quick-stop to be triggered e.g. opened robot cage.]
Master Controller has commanded a servo-stop	Check the activity state of the master control system's emergency stop. [Correct the event which caused the quick-stop to be triggered e.g. opened robot cage.]

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10.5.10 Warning Type: Ub (Stepper or Inc. Encoder Warning) on 7-segment Display

The Ub warning is displayed when the incremental encoder or stepper motor interface cable is disconnected. The T200 can still generate motor torque when Ub is displayed.

Table 23: Causes of Ub on 7-segment Display

Cause	Check/[Correction]
J5 Cabling Mis-wired or Disconnected	The pins at J5 have been mis-wired or the cabling to J5 has become disconnected [Check the wiring requirements in Section 3.16.]
Stepper Interface or Incremental Encoder not Connected	The stepper motor command generation unit or incremental encoder has become disconnected. [Plug in the stepper interface or incremental encoder.]
RS422 Interface voltage levels inadequate	The voltage levels are inadequate. Check: ▪ Recommended cable type or equivalent type is used. Cable with characteristic impedance of 120Ohms is recommended. ▪ Cable Termination of 120Ohms is already provided in the T200. Ensure that no extra termination was provided by the user. ▪ Connection of all pins, especially the GND and Cable-Shield connections, at all connected end of the cabling. ▪ Use a driver with a higher voltage drive capability at the user's control computer end.

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10.5.11 Warning Type: Dot (Thermal Limit Warning) on 7-segment Display

The Dot warning is displayed when the T200 current demand exceeds the thermal current limit that was derived from a variety of sources. The T200 can generate torque in the motor when Dot is present.

Table 24: Causes of Dot on 7-segment Display

Cause	Check/[Correction]
Motor 'Thermistor-Present' Parameter Incorrectly Configured	The T200 has been configured for a non-Moog motor. The user must tell the T200 if the motor uses a Negative Temperature Coefficient (NTC) Thermistor. This parameter may have been mis-configured. [Using the 'SNM' command on the Hand Held Terminal, to change the polarity of the Motor-Thermistor Present flag. Alternatively via the Win-Drive motor icon, non-standard motor entry, change the polarity of the Motor-Thermistor tick box.]
Motor Thermally Limited	Check Fault Type: F6 (Motor Over-Temperature) on 7-Segment Display, for possible sources of thermal limiting due to the motor.
Power Amplifier Thermally Limited	Check Fault Type: F5 (Power Amplifier Over-temperature) on 7-segment Display, for possible sources of power amplifier thermal limiting.
R.M.S. Current Level exceeded	The T200 provides self protection for connectors and other internal devices (See Section 6, Cabling and Interconnect Protection Scheme for an explanation). [See Excessive Load, Movement Duty Cycle is Excessive under Section Warning Type: U6 (External Regen Resistor Warning) on 7-segment Display.]
External Regeneration Resistor Continuous Rating Exceeded	The T200 monitors the external regeneration resistor load cycle to check if its continuous rating is exceeded. Check using the Hand Held Terminal's ?LRR command what is the average power dissipation in the external resistor. Compare this number against the ratings provided in Section 3. [Decrease the duty cycle, by reduction of the acceleration and deceleration, and/or the frequency of the movement.]
Movement Duty Cycle Excessive	The acceleration and deceleration of the movement, as well as the frequency of movement may be excessive for the motor. [Decrease the duty cycle, by reduction of the acceleration and deceleration, and/or the frequency of the movement.]
Motor Undersized	The motor is not rated to handle the current duty cycle required by the application. Use the ?LMR Hand Held terminal command to measure the motor phase r.m.s. current. Check if this is very near the rating of the motor. [Install a motor with a high current rating if this is suitable for the application.]

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10.6 Other Problem Sources

The T200 diagnostics will not identify all problem sources. The following is a list of faults that do not necessarily result in T200 diagnostics messages.

10.6.1 Problem: T200 will not enable

The T200 can be enabled only if all faults have been removed, high power is present, AND if the digital input ENABLE on J1 is activated simultaneously. The E symbol on the 7-segment display indicates that the T200 is enabled.

Table 25: Causes of T200 not enabling

Cause	Check/[Correction]
A.C. Mains or D.C. Bus not present on TB2	A.C. Mains or high voltage D.C. Bus voltage has not been applied. [See Section Fault Type: Mains-Applied LED is not lighting (T200-X10 ONLY) and Section Fault Type: DC-Bus-Active LED is not Lighting.]
ENABLE input on J1 not activated	T200 cannot be enabled without activation of the ENABLE input. Check the status of the ENABLE input using the WinDrive, Drive, Drive-Status menu item is possible. Otherwise check the status of the digital input using a voltmeter or other means, between I_COMMON and ENABLE. [Check the wiring at J1-ENABLE and I_COMMON. Activate the ENABLE digital input, typically by commanding the master control to enable the T200. If using the T200 in standalone 'Point' mode, then activate user supplied safety circuitry to activate the T200 ENABLE.]
T200 Software not Configured	The T200 software has not been configured correctly. [Review Section 5 for a Quick-Start, and Sections 6, 7 and 8 for a detailed overview of set-up procedures. Save the parameter set to non-volatile storage.]
Fault Present	Faults are present. Check the 7-segment display for indication of the faults. [Correct the fault and try to re-enable.]

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10.6.2 Problem: T200 is Enabled, but will not move the Axis

The motor cannot move the axis, though the T200 is already applying high voltage to the motor.

Table 26: Causes of T200 not moving

Cause	Check/[Correction]
Command Source set to 0	The T200 command source is not commanding a movement! Check: • Analogue command voltage wiring to REF+ and REF- is intact. • Voltages between REF+ and REF- on J1 are non-zero. • If using a function generator that the acceleration, velocity, torque and/or position commands are non-zero. • If using CAN, Stepper Interface that the master control computer commands a movement. • If using the Digital Inputs Reference, that the Reference Velocities have been set-up.
Limit Switches activated	See Section Warning Type: U8 (Limit Switches Warning) on 7-segment Display
Brake Applied	The T200 brake is released only if the BRK_IP digital input is activated. If the CAN Reference Source is used, the CAN software MUST also be commanded through the CAN interface to release the brake. [Release the brake by activation of the BRK_IP input on J1. If a CAN system then release the brake via the master control computer.]
Torque Limits Too Low	The user may have programmed too low torque limits to overcome static friction and load stiffness (stiction). Check the present power mode of the T200 using the WinDrive, Drive, Drive Status menu to see if the AUTO_MAN input box is ticked. (If the AUTO_MAN input box is ticked, then the T200 is in Automatic mode). Check the Limits, Manual Mode Disable tick-box to check if Manual Mode has been disabled. [If safe to do so, then the user can disable Manual Mode. Alternatively he can activate the AUTO-MAN mode such that the T200 is placed in Automatic Mode. The Torque and Velocity Limits in the Limits dialog box should be increased if it is safe to do so.]
Motor is Disconnected	The motor is not connected at all to the T200. [DISABLE the T200. Remove all power from the T200 and wait 5 minutes before attempting re-connection. Reconnect the motor power cable to TB8. Re-apply power to the T200. Re-enable and try again to move the axis.]
Fault Present	Faults are present. Check the 7-segment display for indication of the faults. [Correct the fault and try to re-enable.]

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10.6.3 Problem: T200 Movement is not Smooth

The motor moves, but the movement is not smooth.

Table 27: Causes of T200 lack of smoothness

Cause	Check/[Correction]
Motor Phase(s) Disconnected	A loss of a motor phase will cause a non-smooth torque to be applied to the motor. [Disable the T200. Remove all power from the T200 and wait 5 minutes before attempting re-connection. Check the motor power cable connections to TB8. Re-apply power to the T200. Re-enable and try again to move the axis.]
Motor not mounted correctly.	The motor may not be mounted correctly, such that it moves with respect to its mounting flange during the movement. [Disable the T200. Remove all power from the T200 and wait 5 minutes before attempting re-connection. Check the motor mounting arrangements. Tighten all mounting attachments and screws, bolts etc. so that motor movement is not restricted or impossible. Re-apply power to the T200. Re-enable and try again to move the axis.]
Motor or Load Bearings damaged	The motor or load bearings may have become worn or damaged. [Check the motor and load bearings with all power removed. If the motor is damaged, return it to Moog.]
Mechanical Resonance	The mechanic elements of the coupling between motor and load, and the load itself, may be flexible. [Consult Moog Applications engineering for guidance on tuning.]
Shaft Misalignment	The motor and load shafts may be mis-aligned. [Correct the alignment problem.]
Motor Damage	The motor resolver transducer may be damaged or faulty. The motor phases may have partial or total short circuits. [Return the motor to Moog.]
Coupling Damage	The coupling between the Moog motor and the load may be damaged. For example, gearwheel teeth may be broken off. [Replace the coupling mechanism.]

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10.6.4 Problem: Excessive Audible Noise from the Motor

The motor movement is somewhat acceptable, but there is unacceptable high frequency noise from the motor.

Table 28: Causes of Noise in the Motor

Cause	Check/[Correction]
Control Loop Gains are too High	Retune the velocity and position loop gains, so that these are lower in value to reduce the effects of noise. [The P and I gains need to be set at lower values which are still appropriate for the load (see Section 6.6.2, Velocity Loop Tuning). The G gain may need to be reduced (see Section 6.6.3, Position Loop Tuning).
Excessive Noise Pickup on the Resolver Position Sensor Cable	Low noise content on the resolver position feedback signals is critical for good servo-performance. Check the display of velocity on an analogue test point TP2 or using the WinDrive data-logger. Note that about 10RPM of noise is normal because of Analogue to Digital conversion accuracy and other quantisation effects. [Check the following: ▪ [Ensure that all resolver cable wires are properly connected at J6 of the T200. (see Section 3.14 for pinouts). ▪ Ensure that the resolver cable shield is connected at both the motor to Protective Earth and the T200 end to the chassis via a J6 as detailed in Section 3.14. ▪ If the resolver cable run from the motor is alongside the motor power cable, try to separate the cable runs wherever possible.]
T200 Chassis is not well earthed	Ensure that the connection between the T200 Chassis and Protective Earth is as low resistance (and impedance) as possible. [Use a braided wire, or low AWG wire to connect the T200 chassis to Earth. A PE connection point is provided at the top right hand side of the T200's front panel (see Section 3.4 for a diagram of the Front Panel) to augment the TB2 PE connection point. Alternatively use a high conductivity common metal mounting panel for all T200's, so that there is a good low impedance conduction path for high frequency noise away to Protection Earth. For best results resistance should be less than 0.1Ohms to Protective Earth from the T200 chassis.]
Motor Body is not well earthed	High frequency currents flow in the motor internal windings. The motor body should be connected to a metallic path to Protective Earth, to conduct high frequency capacitively-coupled noise generated in the motor, which would otherwise flow in motor power cables lines and shields. [Ensure that the motor has a low resistance path to Protective Earth, with the motor power cable disconnected. For best results resistance should be less than 0.1Ohms to Protective Earth from the motor's metallic body.]
Motor Power Cable shield not well Terminated	For best noise shielding results, the motor cable shield should be connected at BOTH ends of the cable (to the T200 chassis through the PE connection or through the EMC bracket as shown in Section 3.14.5, and to the motor body at the motor end). If the motor shield cannot be connected at the motor end, then the EMC bracket should be used, as shown in Section 3.14.5 and 3.14.6.
Damaged Motor Bearings	Remove all power from the T200. If possible remove the motor from the machine and check the motor can rotate freely by hand, if the motor does not have a brake. Check if there is radial play in the motor shaft with respect to the motor housing. [Return the motor to Moog for repair.]

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10.6.5 Problem: Motor Shaft rotates in the Wrong Direction

The motor movement is reversed in direction from that desired.

CAUTION: Reversal of the direction of rotation can lead to positive feedback and runway conditions of control loops, as part of the system control loop is closed outside of the T200. Ensure that the direction of rotation is well understood before changing polarity of rotation.

Table 29: Causes of Direction Reversal

Cause	Check/[Correction]
ROT_DIR digital Input activated	The rotation direction has been activated, which reverses the polarity of the analog input command, and the digital references velocities. Check the polarity of the ROT_DIR input using the WinDrive Drive, Drive-Status menu item. [Change the state of the ROT_DIR digital input to reverse the motor.]
Swapped REF± differential analog input pins	The polarity of rotation can be changed by swapping the cable connections to the REF+ and REF- inputs.
ESM Polarity reversed	When the ESM Channel A leads Channel B, as shown in Section 6.9 Encoder Simulation Function, the motor rotates in a clockwise direction as described in Section 6.2 T200 Conventions. If A+ and A- are swapped (similarly for B+ and B-) inadvertently by the user, then Channel B will appear to lead Channel A when viewed by the user. [Check all ESM cable wiring to ensure proper of wiring.]
Motor Wiring Reversal	The motor phase wiring may be swapped. Remove all power from the T200. Check the motor phases wiring against Figure 3.32 and Table 3.7. [Correct the wiring.]

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10.6.6 Problem: No ESM Position Feedback from the T200

The motor moves but the encoder simulation feedback does not appear to move.

Table 30: Causes of no ESM Feedback

Cause	Check/[Correction]
No user-supplied external 5V Power Supply	The RS422 type outputs on the T200 are isolated from the T200 control section. A user-supplied 5V must be available to supply power to the isolated side of these RS422 drivers. [See Section 6.9 Encoder Simulation for a description of the wiring and a block diagram.]
Mis-wiring or Disconnected Cable	[See Section 6.9 Encoder Simulation for a description of the wiring and a block diagram.]

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SECTION 11: USER INFORMATON

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11.1 Technical Support

Technical support for Windrive and Moog Brushless DC Motor Drive products is available by contacting MOOG at one of the following addresses: -

Europe and Asia
MOOG GmbH
Hanns-Klemm-Strasse 28
71034 Boeblingen
GERMANY
phone: +0049 - 7031 - 622 -0
fax: +0049 - 7031 - 622 - 100

North America
MOOG INC / Industrial Controls Division
Seneca and Jamison Roads
East Aurora, NY 14052
USA
phone: +001 - 716 - 655 - 3000
fax: +001 - 716 - 687 - 4870

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APPENDIX A: EMC TEST CONFIGURATIONS

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Appendix A:- Test Configurations for EMC-related CE-Compliance

The T200 Series Motor Controllers are system components which must be installed in a correct manner to ensure that all electromagnetic compatibility (EMC) requirements are met. The requirements of European Union (EU) EMC Directive: 89/336/EEC, as amended, must be met by all equipment, systems and installations into which the T200 Series Motor Controllers are installed.

The T200 Series Motor Controllers have been tested for compliance with the EU EMC Directive in so far as they can be regarded as single functional units. The T200 Series Motor Controllers have been tested in typical configurations and it has been found that these configurations meet the essential requirements of the EU EMC Directive.

Test Configuration 1: EMC Emissions: 3 Phase Power application.

The configuration consisted of a Model T200-310 Drive and two Model T200-300 Drives. The Drives were connected to Motors via 10m Motor Power and Motor Resolver shielded cables, terminated to chassis earth at each end. One T200-300 had a motor brake option installed with cable connection to the MOTOR BRAKE port

All drives were driven by an external CANBUS (CAN) test computer connected via a 30m shielded cable to the T200-310 Drive and daisy chained via the CAN IN and CAN OUT ports to the two T200-300 Drives. There was a Steward type 28A2024-0A0 ferrite installed through 1.5urns on the 30m shielded cable at the T200-310 port.

There were 3m shielded cables terminated in characteristic impedances connected to the following ports on all Drives: Encoder port, ESM Out port, Serial port, Axis Signals port. There was an in-line FairRite Type 0443164151 ferrite installed at each end of the Axis Signal port cables for each Drive. There was a 3m shielded cable terminated in characteristic impedances connected to the Power Ready port on the T200-310 Drive.

Input power was supplied via a 3 phase 400:230 V a.c. step down isolation transformer connected by armoured cable to the AC LINE IN port on the T200-310 Drive. The DC BUS voltage was daisy chained from the T200-310 Drive to the two T200-300 Drives.

An optional 24Vd.c. control backup supply was connected to the 24Vd.c. control backup port of the T200-310 and daisy-chained to the two T200-300's. A Steward 28A2024-0A0 ferrite was installed through 2.5turns on the external 24Vd.c supply cable at the T200-310 port. This external 24Vd.c. power supply was supplied from a connection to one of the secondary phases of the 400:230Va.c. step down transformer.

All Drives were mounted onto an earthed metal panel mounted in turn onto an earthed equipment chassis frame. The bare metal rear panel of each Drive enclosure was fixed in direct contact with the earthed metal panel on the equipment chassis.

Output cables were grouped and routed along the chassis of the equipment frame in a manner similar to cable routing on machinery. The motor power and motor resolver cables were grouped together and installed in a fixed routing to the motors. The output port cables, motor power and resolver cables, and power input cables had segregated routings.

Test Configuration 2: EMC Emissions: 3 Phase Power application.

The configuration consisted of a Model T200-410 Drive and Model T200-400 Drive. The T200-400 Drive had a T200 Personality Module option (Moog p/n C09951) installed. The Drives were connected to Motors via 10m Motor Power and Motor Resolver shielded cables, terminated to chassis earth at each end.

There were 3m shielded cables terminated in characteristic impedances connected to the following ports on all Drives: Encoder port, ESM Out port, Serial port, Axis Signals port. There was an in-line FairRite Type 0443164151 ferrite installed at each end of the Axis Signal port cables for each Drive.

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There was a 3m shielded cable terminated in characteristic impedances connected to the Power Ready port on the T200-410 Drive. There were 3m shielded cables terminated in characteristic impedances connected to the CAN IN port on the T200-410 Drive and the CAN OUT port on the T200-400 Drive and a daisy chain connection from the T200-410 CAN OUT port to the T200-400 CAN IN port.

Input power was supplied via a 3 phase 400:230 V a.c. step down isolation transformer connected by armoured cable to the AC LINE IN port on the T200-410 Drive. The DC BUS voltage was daisy chained from the T200-410 Drive to the T200-400 Drive.

An optional 24V d.c. external logic power supply was connected to the 24V DC LOGIC POWER port on the T200-410 Drive and daisy chained to the T200-400 Drive. This external 24 V d.c power was supplied from a power supply on the equipment connected to one of the secondary phases of the 400:230 V a.c. step down isolation transformer.

All Drives were mounted onto an earthed metal panel, mounted in turn onto an earthed equipment chassis frame. The bare metal rear panel of each Drive enclosure was fixed in direct contact with the earthed metal panel on the equipment chassis.

Output cables were grouped and routed along the chassis of the equipment frame in a manner similar to cable routing on machinery. The motor power and motor resolver cables were grouped together and installed in a fixed routing to the motors. The output port cables, motor power and resolver cables, and power input cables had segregated routings.

Test Configuration 3: EMC Emissions: 3 Phase Power application.

The configuration consisted of a Model T200-510 Drive and Model T200-500 Drive. The T200-510 Drive had a T200 Point Extended I/O Card option (Moog p/n C09950) and external regen resistor option installed. The Drives were connected to Motors via 10m Motor Power and Motor Resolver shielded cables, terminated to chassis earth at each end.

There were 3m shielded cables terminated in characteristic impedances connected to the following ports on all Drives: Encoder port, ESM Out port, Serial port, Axis Signals port. There was an in-line FairRite Type 0443164151 ferrite installed at each end of the Axis Signal port cables for each Drive. There was a 3m shielded cable terminated in characteristic impedances connected to the Power Ready port on the T200-510 Drive.

There were 3m shielded cables terminated in characteristic impedances connected to the CAN IN port on the T200-510 Drive and the CAN OUT port on the T200-500 Drive and a daisy chain connection from the T200-510 CAN OUT port to the T200-500 CAN IN port. There was a 3m shielded cable terminated in characteristic impedances connected to the Point Extended I/O option port on the T200-510 Drive. There was an in-line FairRite Type 0443164151 ferrite installed at each end of this cable.

Input power was supplied via a 3 phase 400:230 V a.c. step down isolation transformer connected by armoured cable to the AC LINE IN port on the T200-510 Drive. The DC BUS voltage was daisy chained from the T200-510 Drive to the T200-500 Drive. An optional external Regen resistor was connected via a 10m shielded cable to the EXT REGEN port on the T200-510 Drive.

An optional 120V a.c. external logic power supply was connected to the 120 V AC LOGIC POWER port on the T200-510 Drive and daisy chained to the T200-500 Drive. This external 120 V a.c power was supplied from a 230:120 V a.c. step down isolation transformer on the equipment connected to one of the secondary phases of the 400:230 V a.c. step down isolation transformer.

All Drives were mounted onto an earthed metal panel, mounted in turn onto an earthed equipment chassis frame. The bare metal rear panel of each Drive enclosure was fixed in direct contact with the earthed metal panel on the equipment chassis.

Output cables were grouped and routed along the chassis of the equipment frame in a manner similar to cable routing on machinery. The motor power and motor resolver cables were grouped together and installed in a fixed routing to the motors. The output port cables, motor power and resolver cables, and power input cables had segregated routings.

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Test Configuration 4: EMC Emissions: 3 Phase Power application.

The configuration consisted of a Model T200-410 Drive and Model T200-400 Drive plus a Model T200-510 Drive and Model T200-500 Drive. The T200-400 Drive had a T200 Personality Module option (Moog p/n C09951) installed. The T200-510 Drive had a T200 Point Extended I/O Card option (Moog p/n C09950) and external regen resistor option installed. The Drives were connected to Motors via 10m Motor Power and Motor Resolver shielded cables, terminated to chassis earth at each end.

There were 3m shielded cables terminated in characteristic impedances connected to the following ports on all Drives: Encoder port, ESM Out port, Serial port, Axis Signals port. There was an in-line FairRite Type 0443164151 ferrite installed at each end of the Axis Signal port cables for each Drive. There were 3m. shielded cables terminated in characteristic impedances connected to the Power Ready ports on the T200-410 and T200-510 Drives.

There were 3m shielded cables terminated in characteristic impedances connected to the CAN IN port on the T200-410 Drive and the CAN OUT port on the T200-400 Drive and a daisy chain connection from the T200-410 CAN OUT port to the T200-400 CAN IN port. There were 3m shielded cables terminated in characteristic impedances connected to the CAN IN port on the T200-510 Drive and the CAN OUT port on the T200-500 Drive and a daisy chain connection from the T200-510 CAN OUT port to the T200-500 CAN IN port.

There was a 3m shielded cable terminated in characteristic impedances connected to the Point Extended I/O option port on the T200-510 Drive. There was an in-line FairRite Type 0443164151 ferrite installed at each end of this cable. The Drives were connected to the Motors via 10m. Motor Power and Motor Resolver shielded cables terminated to chassis earth at each end.

Input power was supplied via a 3 phase 400:230 V a.c. step down isolation transformer connected independently by armoured cable to the AC LINE IN ports on the T200-410 and T200-510 Drives. The DC BUS voltage was daisy chained from the T200-410 Drive to the T200-400 Drive and from the T200-510 Drive to the T200-500 Drive. An optional external Regen resistor was connected via a 10m shielded cable to the EXT REGEN port on the T200-510 Drive.

An optional 24V d.c. external logic power supply was connected to the 24V DC LOGIC POWER port on the T200-410 Drive and daisy chained to the T200-400 Drive. This external 24 V d.c power was supplied from a power supply on the equipment connected to one of the secondary phases of the 400:230 V a.c. step down isolation transformer.

An optional 120V a.c. external logic power supply was connected to the 120 V AC LOGIC POWER port on the T200-510 Drive and daisy chained to the T200-500 Drive. This external 120 V a.c power was supplied from a 230:120 V a.c. step down isolation transformer on the equipment connected to one of the secondary phases of the 400:230 V a.c. step down isolation transformer.

All Drives were mounted onto an earthed metal panel, mounted in turn onto an earthed equipment chassis frame. The bare metal rear panel of each Drive enclosure was fixed in direct contact with the earthed metal panel on the equipment chassis.

Output cables were grouped and routed along the chassis of the equipment frame in a manner similar to cable routing on machinery. The motor power and motor resolver cables were grouped together and installed in a fixed routing to the motors. The output port cables, motor power and resolver cables, and power input cables had segregated routings.

Test Configuration 5: EMC Immunity: 3 Phase Power application.

The configuration consisted of a Model T200-310 Drive and two Model T200-300 Drives plus a Model T200-410 Drive and Model T200-400 Drive plus a Model T200-510 Drive and Model T200-500 Drive. The Drives were connected to Motors via 10m Motor Power and Motor Resolver shielded cables, terminated to chassis earth at each end.

The Model T200-310 Drive and two Model T200-300 Drives were driven by an external CANBUS (CAN) computer connected via a 30m shielded cable to the T200-310 Drive and daisy chained via the CAN IN and CAN OUT ports to the two T200-300 Drives. There was a Steward 28A2024-0A0 ferrite installed through 1.5turns on the 30m shielded

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cable of the T200-310 CAN-IN port. One T200-300 had a motor brake option installed with cable connection to the MOTOR BRAKE port

The T200-400 Drive had a T200 Personality Module option (Moog p/n C09951) installed. The T200-510 Drive had a T200 Point Extended I/O Card option (Moog p/n C09950) and external regen resistor option installed.

There were 3m shielded cables terminated in characteristic impedances connected to the following ports on all Drives: Encoder port, ESM Out port, Serial port, Axis Signals port. There was an in-line FairRite Type 0443164151 ferrite installed at each end of the Axis Signal port cables for each Drive. There were 3m. shielded cables terminated in characteristic impedances connected to the Power Ready ports on the T200-310, T200-410 and T200-510 Drives.

There were 3m shielded cables terminated in characteristic impedances connected to the CAN IN port on the T200-410 Drive and the CAN OUT port on the T200-400 Drive and a daisy chain connection from the T200-410 CAN OUT port to the T200-400 CAN IN port. There were 3m shielded cables terminated in characteristic impedances connected to the CAN IN port on the T200-510 Drive and the CAN OUT port on the T200-500 Drive and a daisy chain connection from the T200-510 CAN OUT port to the T200-500 CAN IN port.

There was a 3m shielded cable terminated in characteristic impedances connected to the Point Extended I/O option port on the T200-510 Drive. There was an in-line FairRite Type 0443164151 ferrite installed at each end of this cable.

Input power was supplied via a 3 phase 400:230 V a.c. step down isolation transformer connected independently by armoured cable to the AC LINE IN ports on the T200-310, T200-410 and T200-510 Drives. The DC BUS voltage was daisy chained from the T200-310 Drive to the two T200-300 Drives, from the T200-410 Drive to the T200-400 Drive and from the T200-510 Drive to the T200-500 Drive. An optional external Regen resistor was connected via a 10m shielded cable to the EXT REGEN port on the T200-510 Drive.

An optional 24V d.c. external logic power supply was connected to the 24V DC LOGIC POWER port on the T200-410 Drive and daisy chained to the T200-400 Drive. This external 24 V d.c power was supplied from a power supply on the equipment connected to one of the secondary phases of the 400:230 V a.c. step down isolation transformer.

An optional 120V a.c. external logic power supply was connected to the 120 V AC LOGIC POWER port on the T200-510 Drive and daisy chained to the T200-500 Drive. This external 120 V a.c power was supplied from a 230:120 V a.c. step down isolation transformer on the equipment connected to one of the secondary phases of the 400:230 V a.c. step down isolation transformer.

All Drives were mounted onto an earthed metal panel, mounted in turn onto an earthed equipment chassis frame. The bare metal rear panel of each Drive enclosure was fixed in direct contact with the earthed metal panel on the equipment chassis.

Output cables were grouped and routed along the chassis of the equipment frame in a manner similar to cable routing on machinery. The motor power and motor resolver cables were grouped together and installed in a fixed routing to the motors. The output port cables, motor power and resolver cables, and power input cables had segregated routings.

Test Configuration 6: Supplementary EMC Emissions & Immunity: Single Phase Power Application.

The configuration consisted of a Model T200-310 Drive and two Model T200-300 Drives. The Drives were connected to Motors via 10m Motor Power and Motor Resolver shielded cables, terminated to chassis earth at each end. One T200-300 had a motor brake option installed with cable connection to the MOTOR BRAKE port

All drives were driven by an external CANBUS (CAN) computer connected via a 30m shielded cable to the T200-310 Drive and daisy chained via the CAN IN and CAN OUT ports to the two T200-300 Drives.

There were 3m shielded cables terminated in characteristic impedances connected to the following ports on all Drives: Encoder port, ESM Out port, Serial port, Axis Signals port. There was an in-line FairRite Type 0443164151 ferrite installed at each end of the Axis Signal port cables for each Drive. There was a 3m shielded cable terminated in characteristic impedances connected to the Power Ready port on the T200-310 Drive.

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Single phase input power was supplied via a Schaffner type FN 350-12-29 mains input line to the AC LINE IN port on the T200-310 Drive. The DC BUS voltage was daisy chained from the T200-310 Drive to the two T200-300 Drives.

An optional 24Vd.c. control backup supply was connected to the 24Vd.c. control backup port of the T200-310 and daisy-chained to the two T200-300's. A Steward 28A2024-0A0 ferrite was installed through 2.5turns on the external 24Vd.c supply cable at the T200-310 port. This external 24Vd.c. power supply was supplied from a connection to one of the secondary phases of the 400:230Va.c. step down transformer.

All Drives were mounted onto an earthed metal panel mounted in turn onto an earthed equipment chassis frame. The bare metal rear panel of each Drive enclosure was fixed in direct contact with the earthed metal panel on the equipment chassis.

Output cables were grouped and routed along the chassis of the equipment frame in a manner similar to cable routing on machinery. The motor power and motor resolver cables were grouped together and installed in a fixed routing to the motors. The output port cables, motor power and resolver cables, and power input cables had segregated routings.

Test Configuration 7: Supplementary EMC Emissions & Immunity: Single Phase Power Application.

The configuration consisted of a Model T200-410 Drive and Model T200-400 Drive. The T200-400 Drive had a T200 Personality Module option (Moog p/n C09951) installed. The Drives were connected to Motors via 10m Motor Power and Motor Resolver shielded cables, terminated to chassis earth at each end.

There were 3m shielded cables terminated in characteristic impedances connected to the following ports on all Drives: Encoder port, ESM Out port, Serial port, Axis Signals port. There was an in-line FairRite Type 0443164151 ferrite installed at each end of the Axis Signal port cables for each Drive.

There was a 3m shielded cable terminated in characteristic impedances connected to the Power Ready port on the T200-410 Drive. There were 3m shielded cables terminated in characteristic impedances connected to the CAN IN port on the T200-410 Drive and the CAN OUT port on the T200-400 Drive and a daisy chain connection from the T200-410 CAN OUT port to the T200-400 CAN IN port.

Single phase input power was supplied via a Schaffner type FN 350-12-29 mains input line to the AC LINE IN port on the T200-410 Drive. The DC BUS voltage was daisy chained from the T200-410 Drive to the T200-400 Drive.

All Drives were mounted onto an earthed metal panel, mounted in turn onto an earthed equipment chassis frame. The bare metal rear panel of each Drive enclosure was fixed in direct contact with the earthed metal panel on the equipment chassis.

Output cables were grouped and routed along the chassis of the equipment frame in a manner similar to cable routing on machinery. The motor power and motor resolver cables were grouped together and installed in a fixed routing to the motors. The output port cables, motor power and resolver cables, and power input cables had segregated routings.

Test Configuration 8: Supplementary EMC Emissions & Immunity: Single Phase Power Application.

The configuration consisted of a Model T200-510 Drive and Model T200-500 Drive. The T200-510 Drive had a T200 Point Extended I/O Card option (Moog p/n C09950) and external regen resistor option installed. The Drives were connected to Motors via 10m Motor Power and Motor Resolver shielded cables, terminated to chassis earth at each end.

There were 3m shielded cables terminated in characteristic impedances connected to the following ports on all Drives: Encoder port, ESM Out port, Serial port, Axis Signals port. There was an in-line FairRite Type 0443164151 ferrite installed at each end of the Axis Signal port cables for each Drive. There was a 3m shielded cable terminated in characteristic impedances connected to the Power Ready port on the T200-510 Drive.

There were 3m shielded cables terminated in characteristic impedances connected to the CAN IN port on the T200-510 Drive and the CAN OUT port on the T200-500 Drive and a daisy chain connection from the T200-510 CAN OUT port

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to the T200-500 CAN IN port. There was a 3m shielded cable terminated in characteristic impedances connected to the Point Extended I/O option port on the T200-510 Drive. There was an in-line FairRite Type 0443164151 ferrite installed at each end of this cable.

Single phase input power was supplied via a Schaffner type FN 350-12-29 mains input line to the AC LINE IN port on the T200-510 Drive. The DC BUS voltage was daisy chained from the T200-510 Drive to the T200-500 Drive. An optional external Regen resistor was connected via a 10m shielded cable to the EXT REGEN port on the T200-510 Drive.

All Drives were mounted onto an earthed metal panel, mounted in turn onto an earthed equipment chassis frame. The bare metal rear panel of each Drive enclosure was fixed in direct contact with the earthed metal panel on the equipment chassis.

Output cables were grouped and routed along the chassis of the equipment frame in a manner similar to cable routing on machinery. The motor power and motor resolver cables were grouped together and installed in a fixed routing to the motors. The output port cables, motor power and resolver cables, and power input cables had segregated routings.

Test Configuration 9: EMC Emissions & Immunity: 3 Phase Power application.

The configuration consisted of two Model T200-610 Drives. Both Drives had 8 ohm external regen resistor options installed. The Number Two T200-610 Drive had a T200 Point Extended I/O Card option (Moog p/n C09950) and a T200 Personality Module option (Moog p/n C09951) installed. The Drives were connected to Motors via 10m Motor Power and Motor Resolver shielded cables, terminated to chassis earth at each end.

There were 3m shielded cables terminated in characteristic impedances connected to the following ports on both Drives: Power Ready port, Encoder port, ESM Out port, Serial port, Axis Signals port. There was an in-line FairRite Type 0443164151 ferrite installed at each end of the Axis Signal port cables for each Drive.

There were 3m shielded cables terminated in characteristic impedances connected to the CAN IN port on the Number One T200-610 Drive and the CAN OUT port the Number Two T200-610 Drive. Each of these cables had an in-line Steward Type 28A2024-0A0 ferrite installed at the Drive ports. There was a daisy chain connection from the Number One T200-610 Drive CAN OUT port to the Number Two T200-610 Drive CAN IN port.

There was a 3m shielded cable terminated in characteristic impedances connected to the Point Extended I/O option port on the Number Two T200-610 Drive. There was an in-line FairRite Type 0443164151 ferrite installed at each end of this cable.

Input power was supplied via a 3 phase 400:230 V a.c. step down isolation transformer connected by separate armoured cables to the AC LINE IN port on each T200-610 Drive. The external regen resistors (8 ohm) were connected via 10m. shielded cables to the EXT REGEN port on each T200-610 Drive.

An optional 24V d.c. external logic power supply was connected to the 24V DC LOGIC POWER port on the Number Two T200-610 Drive and daisy chained to the Number One T200-610 Drive. This external 24 V d.c power was supplied from a power supply on the equipment connected to one of the secondary phases of the 400:230 V a.c. step down isolation transformer. There was a Steward Type 28A2024-0A0 ferrite installed through 2.5 turns on the supply cable at the 24V DC LOGIC POWER port on the Number Two T200-610 Drive.

An optional 120V a.c. external logic power supply was connected to the 120 V AC LOGIC POWER port on the Number One T200-610 Drive and daisy chained to the Number Two T200-610 Drive. This external 120 V a.c power was supplied from a 230:120 V a.c. step down isolation transformer on the equipment connected to one of the secondary phases of the 400:230 V a.c. step down isolation transformer. There was an in-line Steward Type 28A2024-0A0 ferrite installed on the supply cable at the 120 V AC LOGIC POWER port on the Number One T200-610 Drive.

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Both Drives were mounted onto an earthed metal panel mounted in turn onto an earthed equipment chassis frame. The bare metal rear panel of each Drive enclosure was fixed in direct contact with the earthed metal panel on the equipment chassis.
Output cables were grouped and routed along the chassis of the equipment frame in a manner similar to routing of cables on machinery. The motor power and motor resolver cables were grouped together and installed in a fixed routing to the motors. The output port cables, motor power and resolver cables, and power input cables had segregated routings.

Single Phase Power Application: Line Filtering (Models T200-3XX, -4XX, -5XX).

An a.c. power input Line Filter is required to be installed by the user in the a.c. power input supply lines. The following power input Line Filter is recommended:

Type: FN 350-12-29, manufactured by Schaffner, Switzerland. (Rated 12 A r.m.s.)

Care must be taken when installing the a.c. power input Line Filter to ensure that the ability of the filter to function effectively is not degraded.

When installing the Line Filter, care must be taken to implement the following measures:

- Install the Line Filter on an earthed metal panel. There must be continuous earth continuity with good HF bonding between this panel and the panel on which the T200 Series Controllers are mounted. This must result in continuous earth continuity with good HF bonding between the enclosure of the Line Filter and the enclosures of the T200 Series Controllers.
- Remove paint or other insulating materials and provide conductive corrosion protection at the mounting points for the Line Filter. Secure the filter using conductive bolts and locking washers.
- Locate the Line filter as close as possible to the T200 Power input connector. Total cable length from Line Filter to the T200 Power input connector should not exceed 1 metre. Keep all cable lengths as short as possible and route separately from other cables and conductors.
- If using shielded or armoured cable for all connections from Line Filter to the T200 Power input connector, the shields of these voltage supply cables should be earthed to Chassis Earth using a 180 degree metal clamp (P clip) connection. Alternatively, if the cable is required to pass through an enclosure panel earthed to Chassis Earth, the shield may be earthed to the panel by use of a 360 degree metal cable gland.
- Ensure that the Line Filter is firmly connected to mains Earth and that the Protective Earth (PE) of the Line Filter is correctly connected to the Protective Earth (PE) of the T200 Series Controllers. Ensure that there is good high-frequency (HF)bonding between enclosure of the Line Filter, T200 Series Controllers and Protective Earth (PE).
- Ensure that input and output cables from the Line Filter are segregated as much as possible to prevent noise coupling. (See figures below). It is essential that the input conductors to the Line Filter be completely segregated from both the filter output conductors and all other cables and conductors in the installed product.

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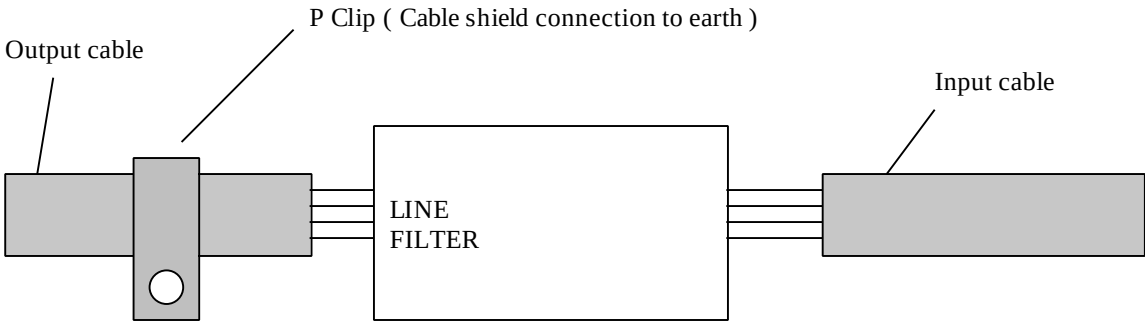
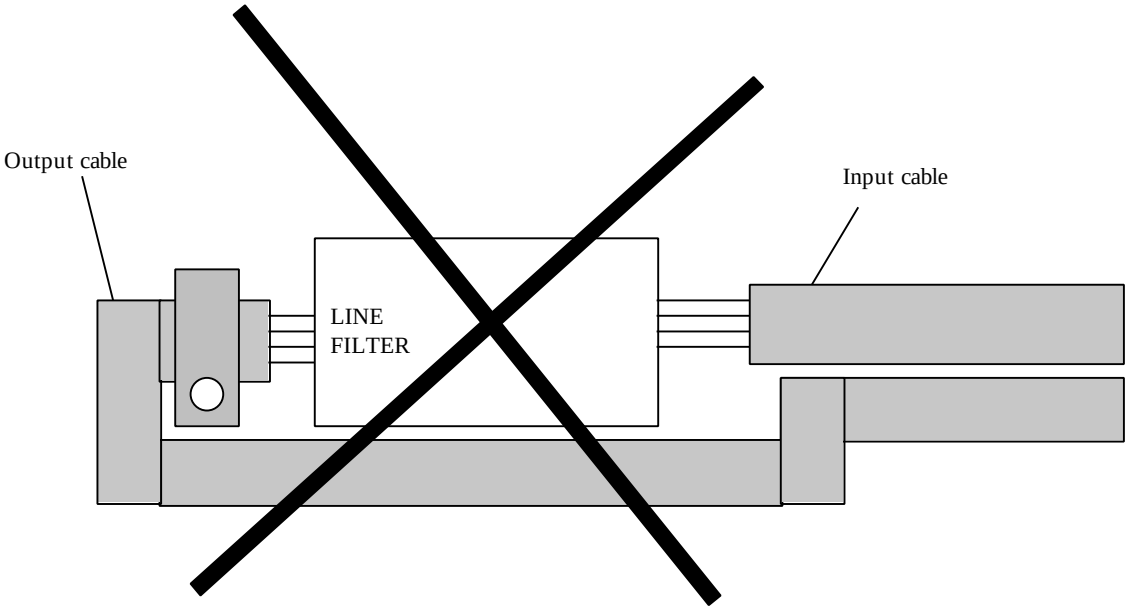


Correct Input/Output Cable Routing



Incorrect Input/Output Cable Routing

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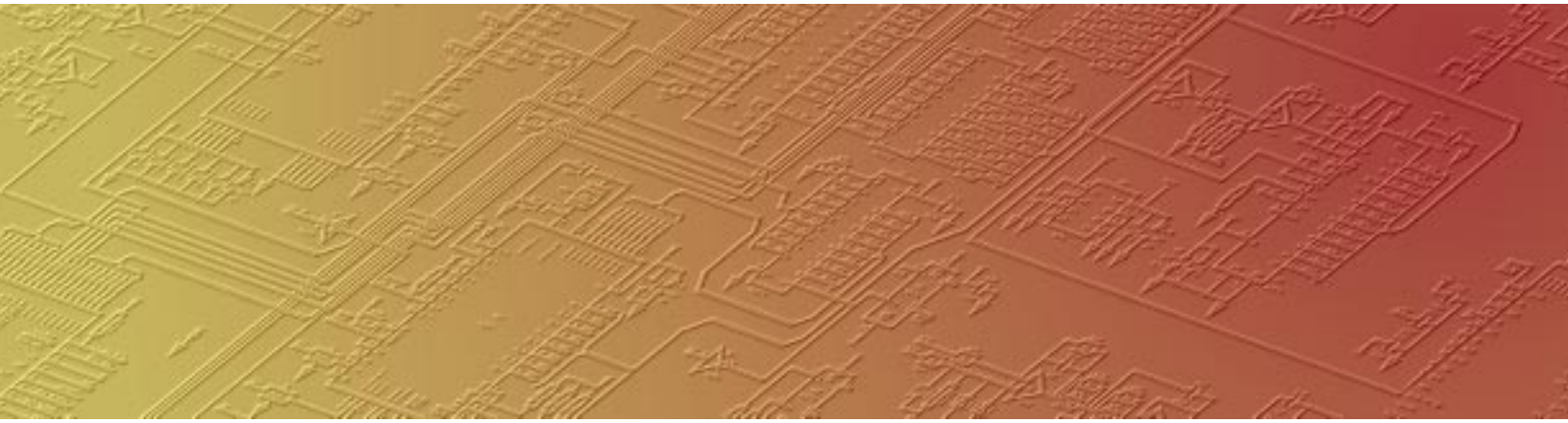

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